Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

JULY, 1955

TECHNOLOGY DEPT.

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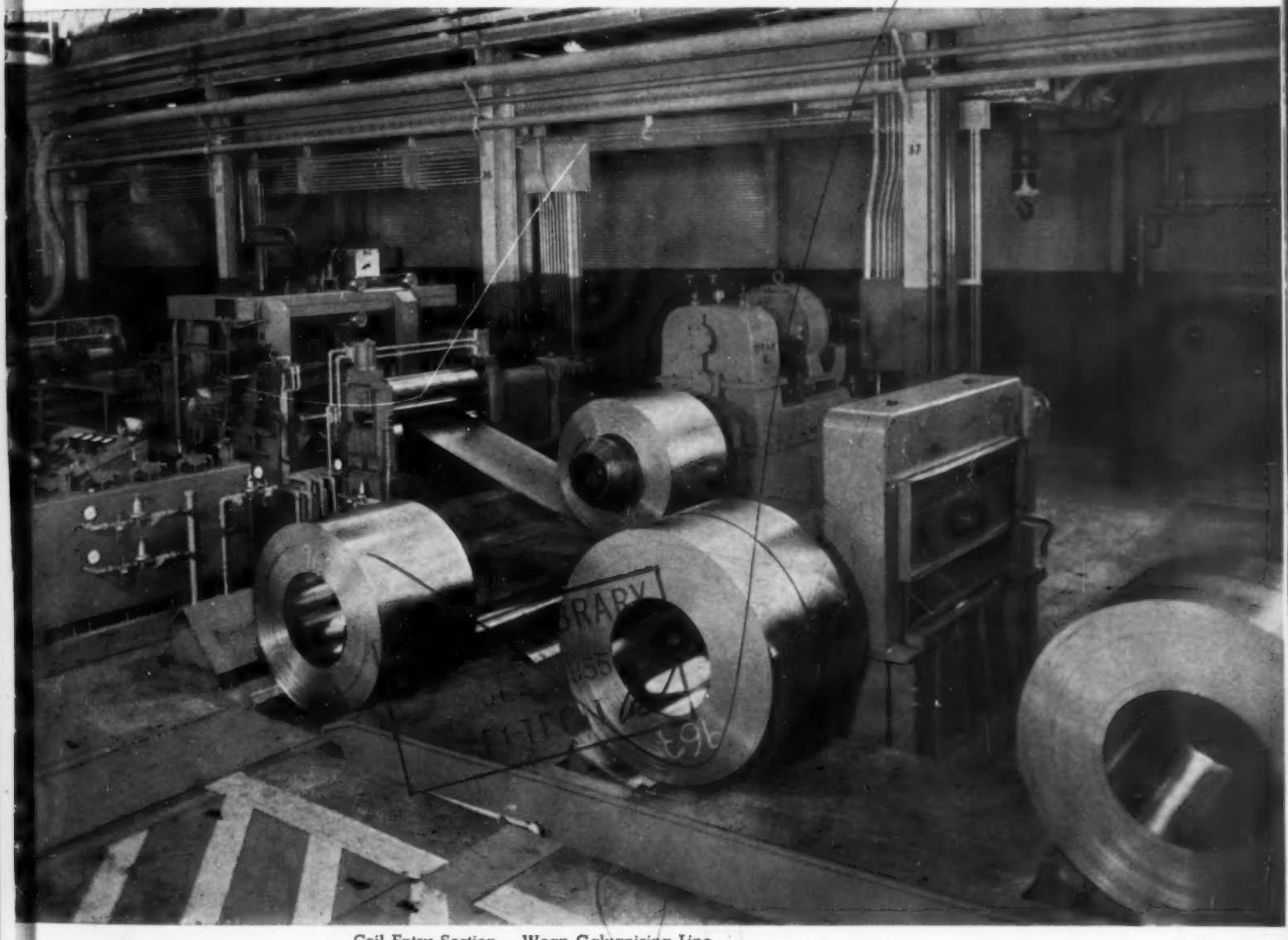

Coil Entry Section — Wean Galvanizing Line

The WEAN ENGINEERING COMPANY · INC.
Warren, Ohio

Typical of Wean Advanced Engineering is this continuous hot dip galvanizing line that produces a vastly improved zinc coat steel at greatly increased speeds. Heavier coatings, tighter bonding and greater uniformity are now possible at reduced costs. It's this kind of never ending search for better ways of making better steel products that has established Wean as the nation's foremost designer and builder of sheet, tin and strip mill equipment.

SPECIALISTS IN SHEET, STRIP AND TIN MILL EQUIPMENT

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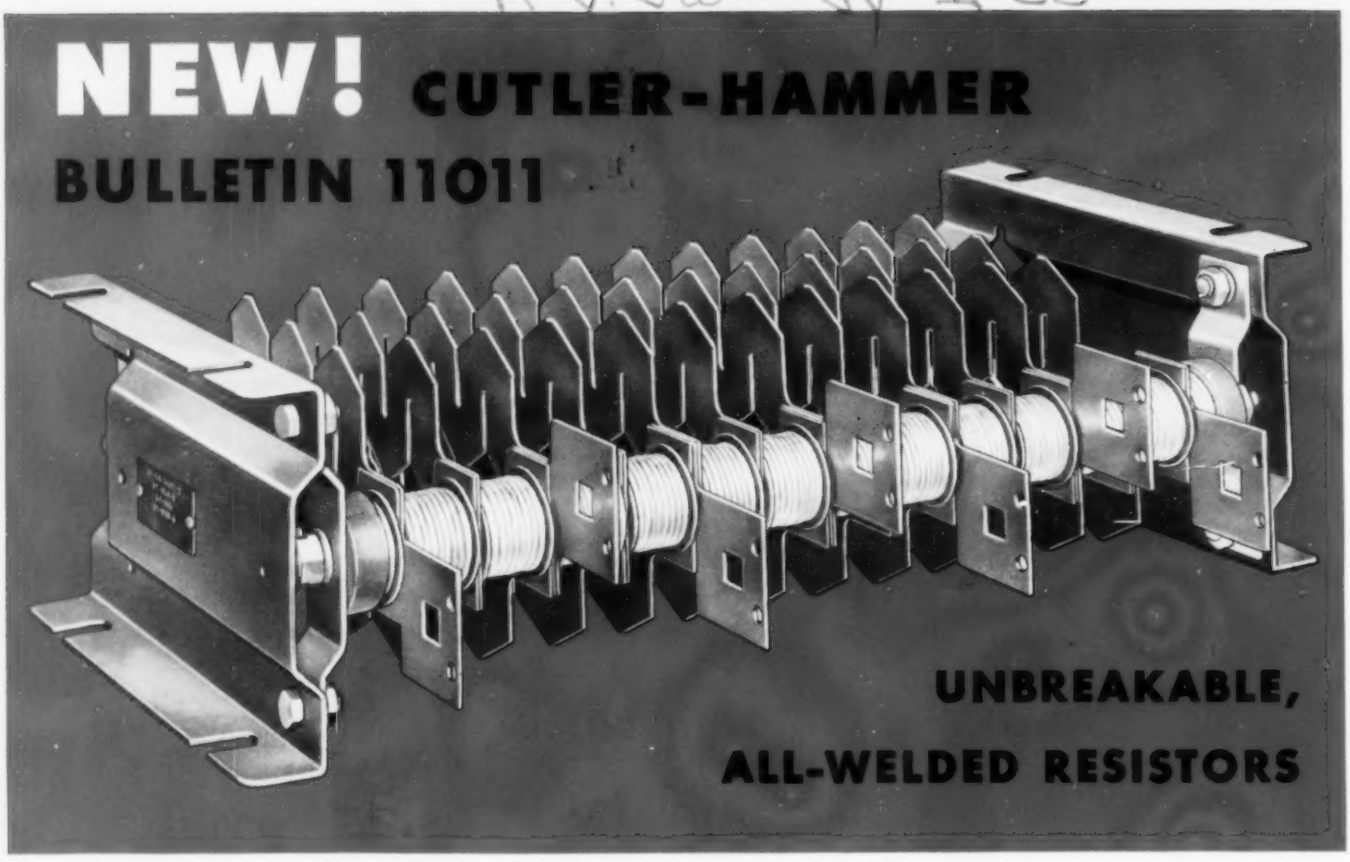

Lower Maintenance Costs, More Stable Resistance Values, Higher Current Capacities

Cutler-Hammer now offers a brand-new unbreakable mill-type resistor with design features that provide an all-welded current path, that stabilize resistance values, afford high current capacities, and resist corrosion and vibration.

The individual grids are punched from a chromium steel alloy and are mounted in an unique over-under arrangement to attain exceptionally efficient heat radiation which permits continuous current capacities up to 187 amperes per box. The low resistance coefficient of the grid alloy results in small resistance change despite grid temperature variation. Grid junctions are seam welded and terminal taps spot welded to insure a continuous current path and to eliminate grid contact troubles. Rugged steel and mica washers are used as grid spacers and insulators.

A radically new type of end plate and grid rod design affords "draw-out" replacement of the grid assembly without disturbing the end plates or other boxes in the resistor stack. This exclusive construction feature also compensates for thermal expansion of the individual grids.

These resistors are available in ratings from 1/10th to 8 ohms. Standard boxes come in 17¾", 22" and 26½" lengths. Terminals provide 10% resistance steps. All resistors are insulated for 600 volt service.

For lower maintenance costs, more stable resistance values, and higher current capacities *standardize on these new Cutler-Hammer Bulletin 11011 Unbreakable Resistors.* CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

CUTLER-HAMMER
MOTOR CONTROL
C-H

Tech

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., Pittsburgh, Pa. Second class mail privileges authorized at Pittsburgh, Pennsylvania, January 25, 1924.

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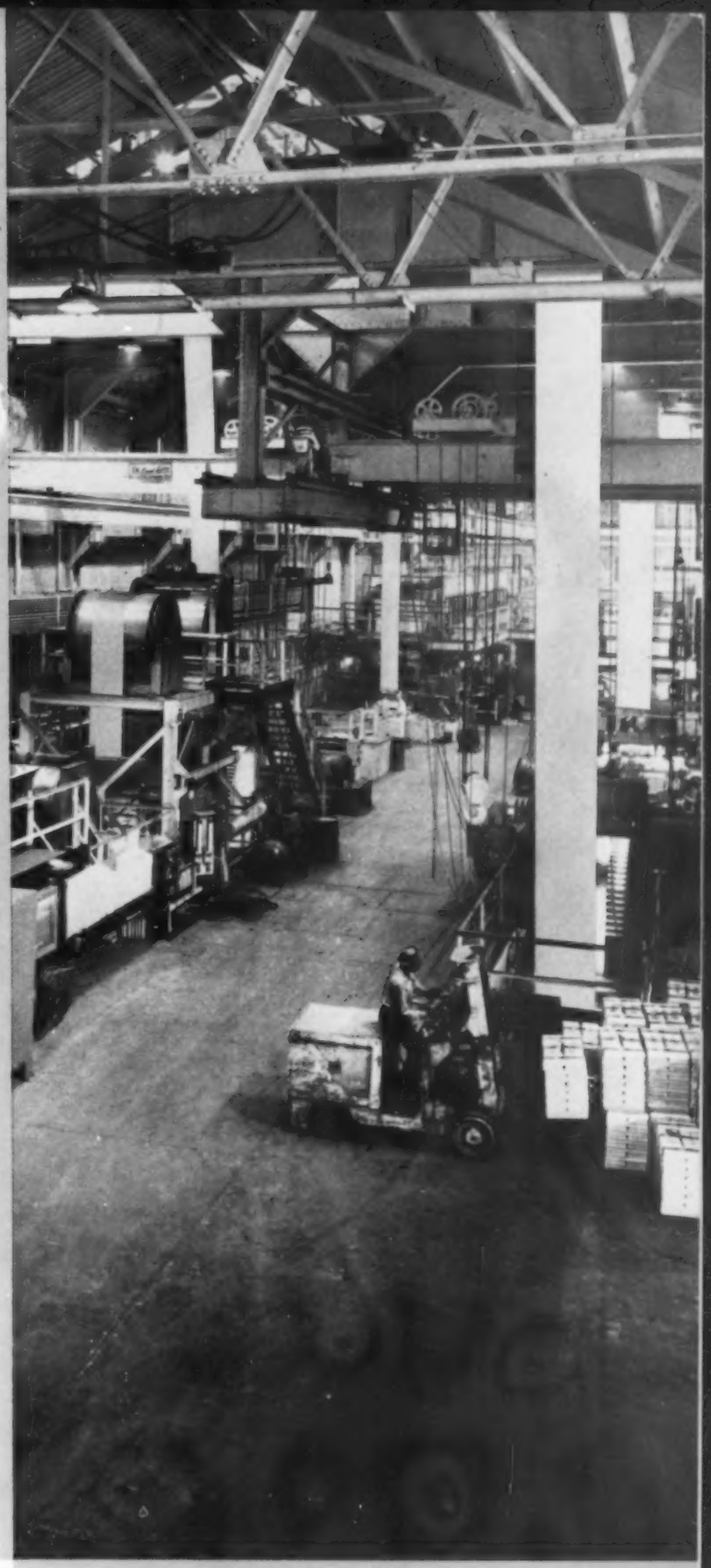


CONTINUOUS GALVANIZING LINES BUILT BY AETNA

● **The 25th Aetna-built Continuous Galvanizing** Line could be yours. If you are considering a Continuous Galvanizing Line, you probably have ideas about the most practical process for your production. The lines offered by Aetna-Standard include all of the different processes and types in use today. This ability to combine specialized knowledge of Continuous Galvanizing with your own specific ideas is a principal reason for Aetna's building more lines than all other manufacturers. Add the most important requirement of all—performance of the equipment, plus integrity and ability to work with people, and you have some of the reasons why more companies select Aetna-Standard than any other manufacturer to build their Continuous Galvanizing Lines.

Will the 25th be yours?

THE AETNA-STANDARD ENGINEERING COMPANY · PITTSBURGH, PA.

Aetna-Standard

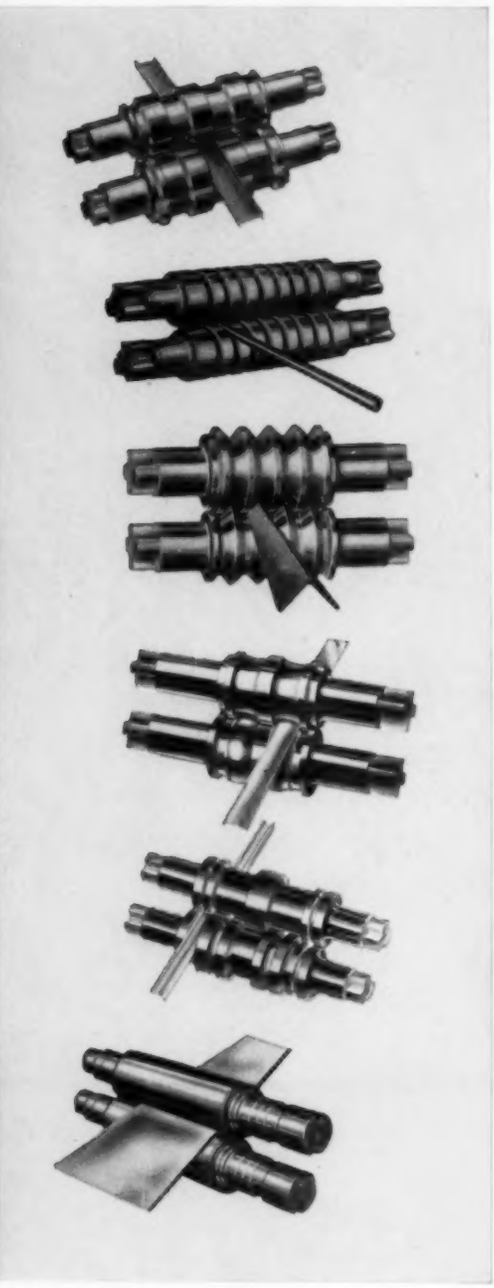
PLANTS IN WARREN, OHIO · ELLWOOD CITY, PENNSYLVANIA

GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

SUBSIDIARY and ASSOCIATED COMPANIES

Head Wrightson Machine Company, Ltd., Middlesbrough, England — Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.
Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.
M. Castellvi, Inc., New York, N. Y. — Mexico, Central and South America.
Societe de Constructions de Montbard, Paris, France — France, Belgium, Holland, Luxembourg, Switzerland.
Demag Aktiengesellschaft, Duisburg, Germany — Germany, Austria, Yugoslavia, Greece, Turkey, Egypt.
Compagnia Italiana Forme Acciaio, Milano, Italy — Italy.
Aetna-Japan Company, Ltd., Tokyo, Japan — Japan.
Hale & Kullgren, Inc., Akron, Ohio — Representative for the Rubber Industry.

Designers and Builders to the Ferrous, Non-Ferrous, Leather, Rubber, and Plastic Industries



POURING Top Quality ROLLS FOR MORE THAN 45 YEARS . . .

. . . Rolls that are sound, long-wearing . . . rolls cast to the right hardness, chill depth, heat resistance . . . iron, alloy iron and steel rolls that you can depend upon to give long tonnage life.

So, for rolls that meet your specifications for soundness and precision be sure to specify National Rolls. You'll be glad you did.

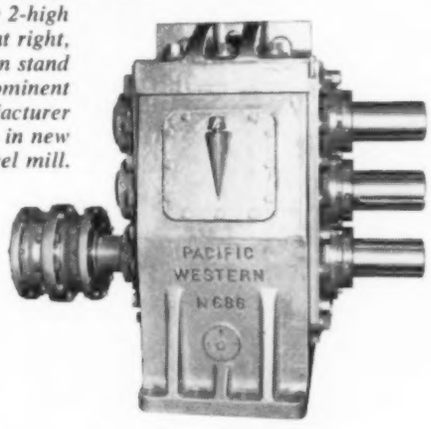
THE NATIONAL ROLL & FOUNDRY CO.
AVONMORE, PENNSYLVANIA

Specialists in Iron, Alloy Iron and Steel Rolls, Carbon, Alloy and Manganese Steel Castings

WESTERN GEAR rolling mill drives ...rugged as Gibraltar!

Western Gear 2500 HP Model S-87-MS speed reducer 5.7:1 ratio utilizing double helical staggered tooth gears.

Above, Western Gear designed double 2-high pinion stand, and at right, single 3-high pinion stand manufactured for prominent mill equipment manufacturer for installation in new Italian steel mill.



Western Gear pinion stands, gear drives and other machinery for application in steel rolling mills are backed by experience accumulated since 1888 in the design and construction of mechanical power transmission equipment of every description. It's your guarantee of ruggedness and trouble-free production day in and day out. Anti-friction bearings provide for rock-steady, vibration-free operation so essential to maintain high standards of accuracy and finish. And this same precision helps prolong the life of related machinery, too! Removable end plates on Western Gear pinion stands enable lifting entire gear train for easy inspection without removing housing from bed plate mounting.
To maintain top quality output with a minimum of downtime and overhead, insist on Western Gear drives for rolling mill application.

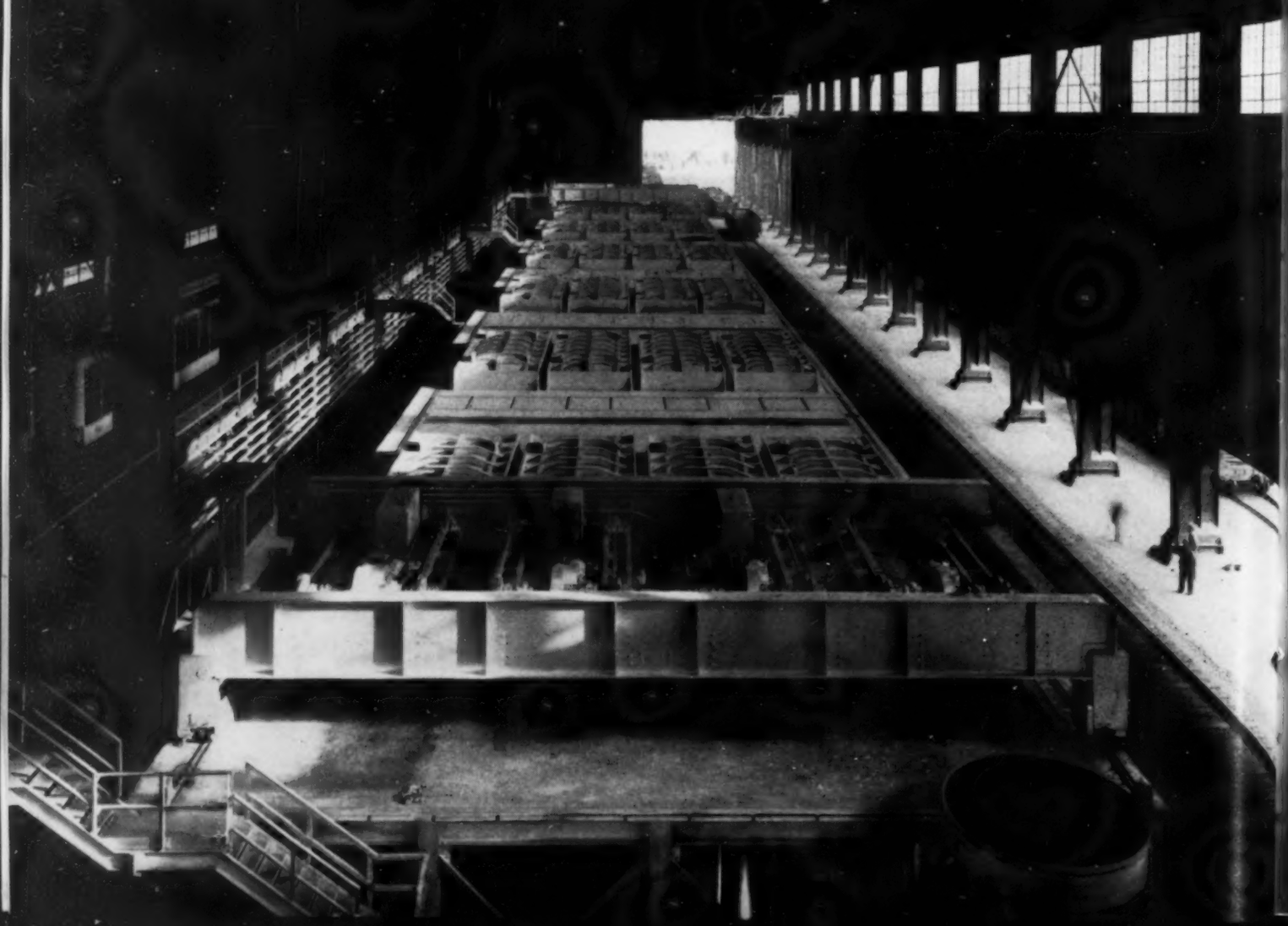
For recommendations on the installation of new equipment or the replacement of obsolete or worn units, write today. Our engineers will be glad to offer their help and experience. Address General Offices, Western Gear, P.O. Box 182, Lynwood, California.

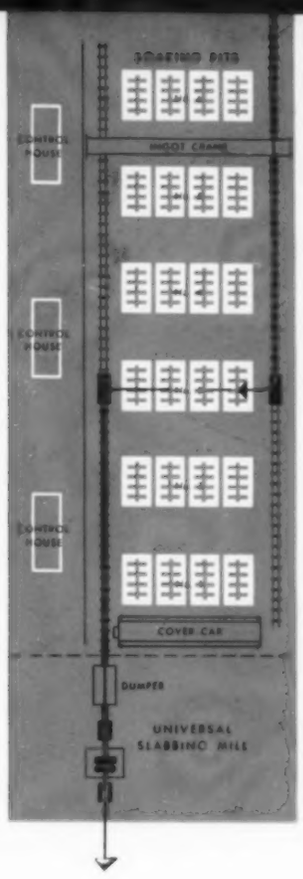
"The difference is reliability" ★ Since 1888 5570

WESTERN GEAR
ENGINEERS AND MANUFACTURERS

PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.) SEATTLE AND HOUSTON—REPRESENTATIVES IN PRINCIPAL CITIES

at Great Lakes, too...





high-production soaking pits

. . . a convincing example of 'Surface' leadership. Behind the story of these 24 soaking pits at Great Lakes Steel, Detroit Division of National Steel Corporation, is an imposing record of achievement: Surface Combustion has built 80% of all new pits since World War II.

At Great Lakes, six batteries, four 'Surface' pits in each, heat low carbon steel ingots for automotive and appliance steel. They also heat some low alloy steel ("NAX" grade).

Repeat order! Great Lakes just ordered 4 more batteries - now 40 pits in this installation.

These one-way-fired pits include such 'Surface' features as the efficient jet pump recuperative system, and integrated temperature and combustion controls which are of the most modern design. The performance of these pits, and many others, is among the reasons why steelmakers depend on 'Surface.'

SURFACE COMBUSTION CORPORATION, TOLEDO, OHIO

Surface
STEEL MILL FURNACES

Foreign affiliate companies:

British Furnaces, Ltd., Chesterfield; Stein & Atkinson, Ltd., London

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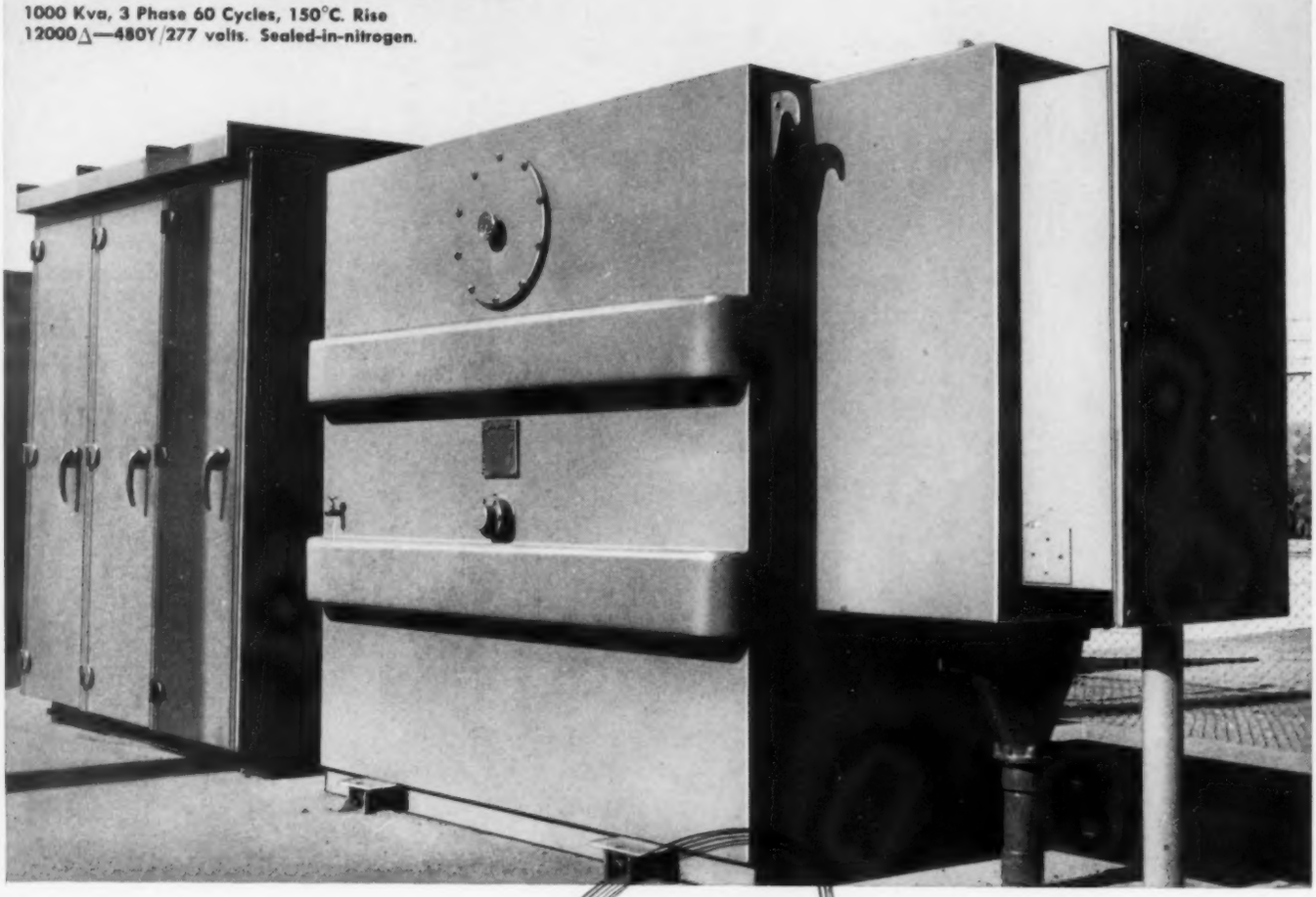
Benno Schilde Maschinenbau, A.G., Bad Hersfeld (Hessen, Germany)

Pennsylvania Class H Transformer installation,
Boeing Airplane Company, Wichita, Kansas.

1000 Kva, 3 Phase 60 Cycles, 150°C. Rise
12000Δ—480Y/277 volts. Sealed-in-nitrogen.



Pennsylvania CLASS H Transformers

Safest transformers ever developed for UNIT SUBSTATIONS NETWORK SYSTEMS GENERATING STATIONS available in the following ratings:

	KVA	VOLTAGE
VENTILATED	UP TO 3000	UP TO 15 KV
SEALED IN NITROGEN	UP TO 2000	UP TO 15 KV

Consider these Advantages:

- No fire or explosion hazards
- Lowest fire insurance rates of any transformer
- Transformer least affected by water
- Exceptionally high overload capacities
- Requires minimum maintenance — even in contaminated areas

For further information on Pennsylvania Class H transformers, we invite you to write to Pennsylvania Transformer Company, Box 330, Canonsburg, Pa., and ask for your free copy of Bulletin 951 — "H . . . in a Class by Itself."

pt PENNSYLVANIA TRANSFORMER COMPANY

A McGraw Electric Company Division • CANONSBURG, PENNSYLVANIA • *Greater Pittsburgh District*

"With this machine we do a better job . . . faster than ever before"

COLUMBIA STEEL AND SHAFTING COMPANY
CARNEGIE, PA.

Three CONTINENTAL-Medart Centerless Turners like this have now been in service for many months at Columbia Steel and Shafting Company. Here's what they say about them: "These machines have materially improved the operation of our production lines. The finish obtained is of consistently high quality. We particularly like the better manipulation of the bars made possible by more automatic handling. In short, they have fully justified their installation."

Here are the features that put this Model RFRG Centerless Turner in a class by itself for high speed, high quality production: New direct-drive roll feed has patented universal centering device that insures continuous, positive feed and automatically centers work. Separate variable drives for feed and cutterhead maintain precise ratio between bar feed and cutter speeds. Automatic input and output grip carriages permit constant feed and delivery without shut-down. Work is simplified and made easier for the operator by fully automatic push button control at his working position.

The CONTINENTAL-Medart Model RFRG Centerless Turner will turn or rough peel ferrous or non-ferrous bars and tubes up to six inches diameter, at throughput speeds limited *only* by the capacity of the cutting tools. Remember—if your operations call for centerless turning or peeling of bars or tubes from 1″ to 10″, there is a CONTINENTAL-Medart to do it—faster, better and at lower cost. Write for information.

CONTINENTAL

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Foundry & Machine
Company

Engineering and Sales Office, 220 Grant St., Pittsburgh 19, Pa.
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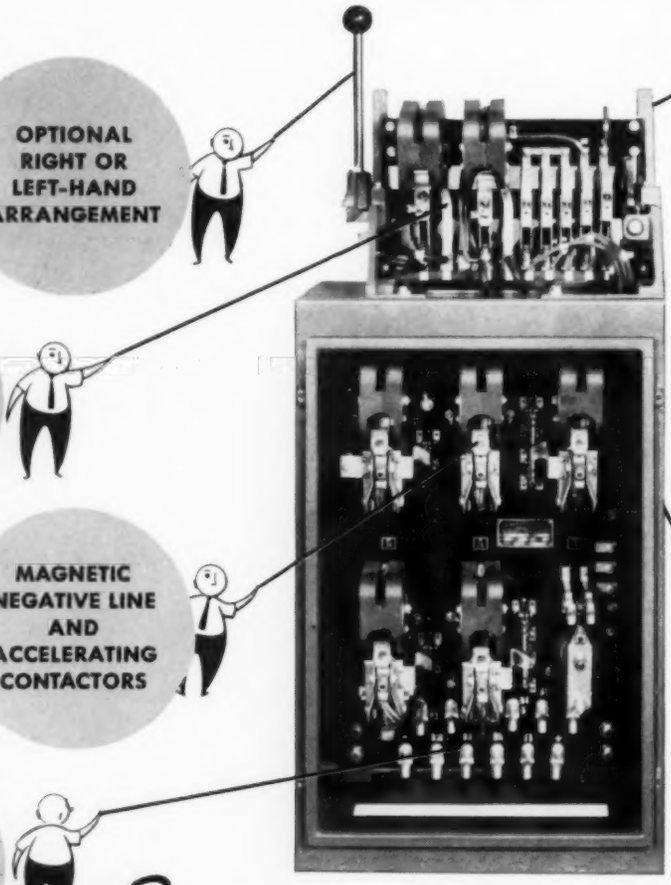
NEW

HEAVY-DUTY D-C MAN-NETIC CONTROLLERS*

Combination Manual and Magnetic Controller for Cranes . . . Charging Machines . . . D-C Control Jobs



OPTIONAL RIGHT OR LEFT-HAND ARRANGEMENT

CAM SWITCH CAN BE MOUNTED REMOTE

HEAVY-DUTY CAM SWITCH WITH REVERSING AND CONTROL CONTACTS . . . "MASTER-SWITCH" EASE OF OPERATION

COMPACT DESIGN ALLOWS INSTALLATION WHERE SPACE IS AT A PREMIUM

MAGNETIC NEGATIVE LINE AND ACCELERATING CONTACTORS

MOTOR AND RESISTOR TERMINALS READILY ACCESSIBLE

TOE SPACE FOR OPERATOR'S COMFORT

2 TYPES AVAILABLE:

REVERSE-PLUGGING OR DYNAMIC-LOWERING

Provide four speed points, reversing, with all advantages of full-magnetic control. Manually-operated cam contacts are free of destructive arcing . . . extremely fast magnetic contactor action interrupts power circuit before cam-operated contacts are opened. EUCLID'S EXCLUSIVE "TIMELOK" feature offers maximum dependable acceleration timing without extra relays . . . permits unusually compact arrangement of the magnetic panel.

For more information, contact our representative in your area, or write or call THE EUCLID ELECTRIC & MFG. CO., MADISON, OHIO.

*PATENT APPLIED FOR

Ask for Bulletin 4400-4401.

THE EUCLID ELECTRIC & MFG. CO.
MADISON, OHIO

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• FIRE ALARM DELIVERY...
• DOWN-TIME CUT TO A MINIMUM!

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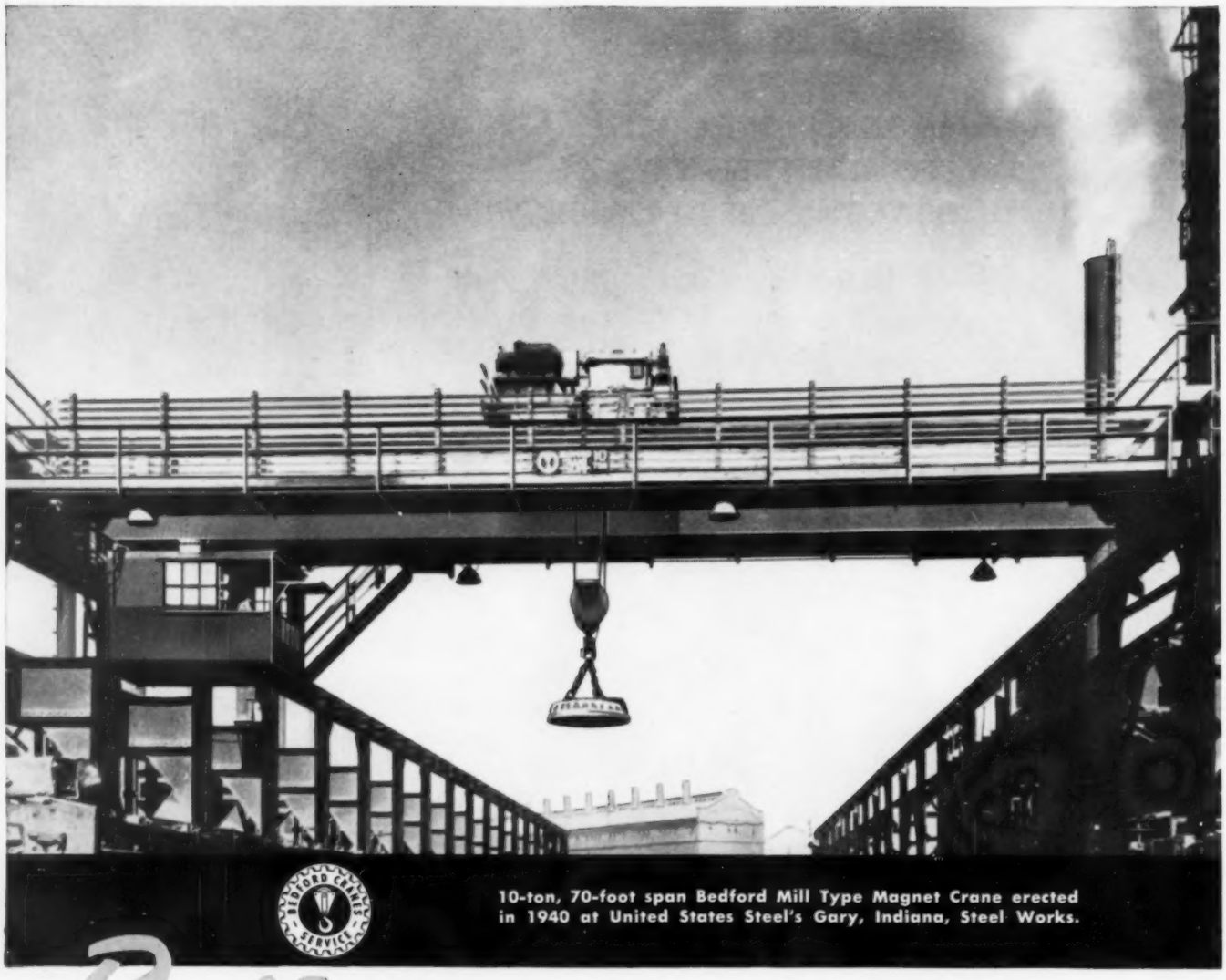


10-ton, 70-foot span Bedford Mill Type Magnet Crane erected in 1940 at United States Steel's Gary, Indiana, Steel Works.

Bedford Mill Type Magnet Crane Rolls Up 15 Years of Dependable Service

In steel mills, power plants and throughout heavy industry . . . wherever superior performance is expected . . . Bedford cranes are standing up to the *tough* job year in and year out.

Further proof of the superiority of Bedford cranes is found in the high percentage of *repeat orders* from important owners through the years.

Built to the most modern standards and backed by more than 53 years of specialized crane building *and utilization* experience . . . Bedford cranes have won fame the world over for advanced design and for safe, smooth, dependable performance.

Available in all types and sizes . . . from 5 tons to 350 tons, and up, for all kinds of indoor and outdoor services . . . each Bedford crane is individually engineered and precision built for its specific application.

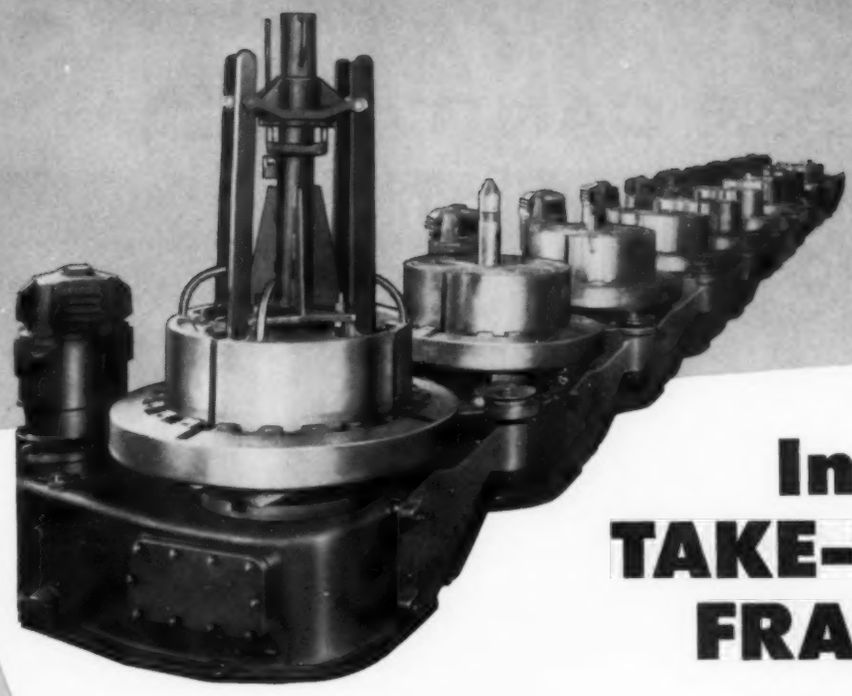
You are invited to consult a Bedford engineer on your next crane problem . . . with all the facts on the table we believe you too will make your next crane a Bedford.

(Write for complete catalog describing Bedford Cranes in detail.)

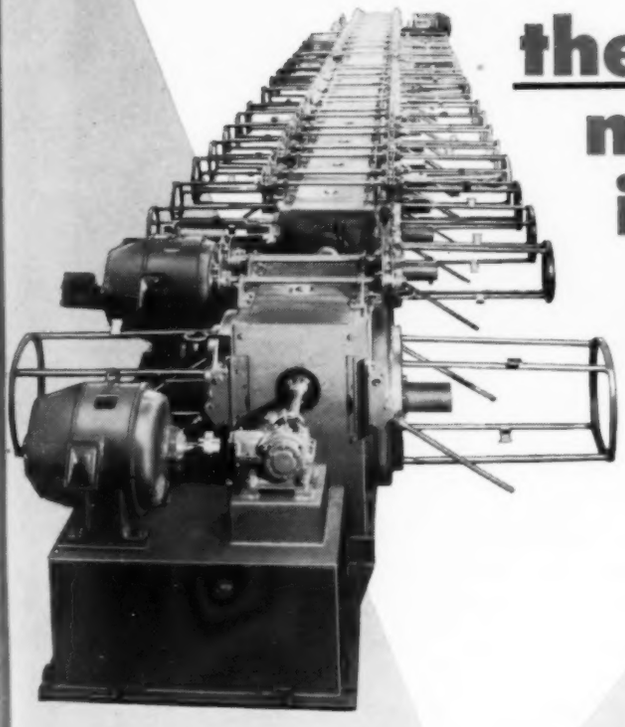
STEEL MILL CRANES BEDFORD

New York Office: 30 Church St., Room 426
New York 7, N. Y., Phone COrtlandt 7-1896
Pittsburgh Office: Oliver Building, Room 1141
Phone ATlantic 1-0136

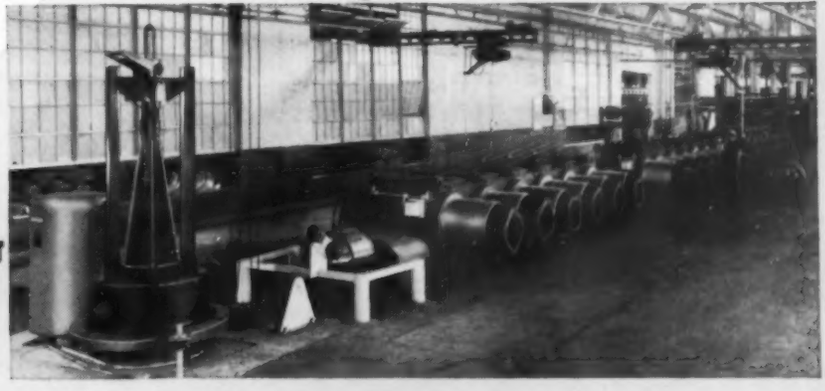
BEDFORD FOUNDRY & MACHINE COMPANY, INC. • BEDFORD, INDIANA

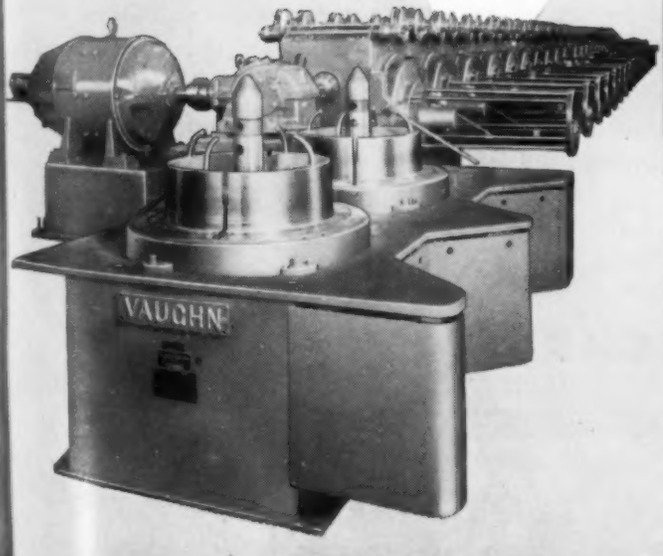


In TAKE-UP FRAMES



the name is- Vaughn®



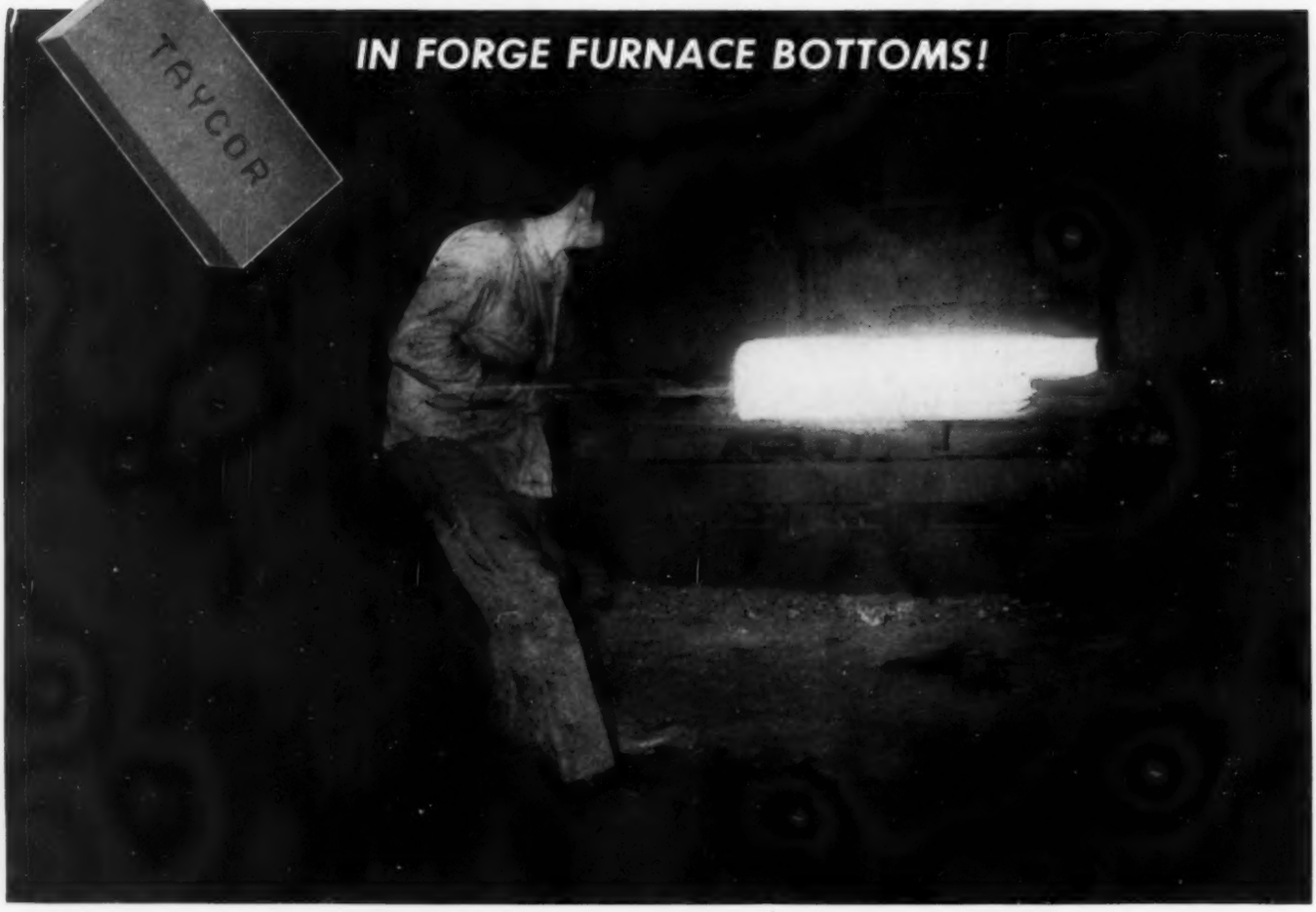


Vaughn Take-Up Frames incorporate the complete experience of the Vaughn organization in manufacturing wire drawing equipment of every type—to the most exacting standards of profitable performance for the customer. *We'll be glad to detail the advantages to you!*

The VAUGHN MACHINERY COMPANY
CUYAHOGA FALLS, OHIO, U. S. A.

COMPLETE COLD DRAWING EQUIPMENT—Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.

TAYCOR CAN TAKE IT



TAYCOR brick bottom still going strong after 1½ years where fireclay fails in from 1 to 8 months!

The forge furnace shown above is one of many operated by a prominent manufacturer of forgings in the Chicago area. Steel pieces, weighing from 50 to 450 lbs., are pushed onto the furnace bottom and are withdrawn the same way. Due to this severe service, fireclay bottom life averaged from one to eight months.

Because of their excellent resistance to heat, abrasion and attack from iron oxide, TAYCOR Brick were installed in this furnace bottom. After more than 1½ years, the TAYCOR bottom was *still in good condition*. There was no grooving—the wear was even throughout—attesting to the abrasion resistance of TAYCOR. As a result, this customer has installed TAYCOR in other furnace hearths.

TAYCOR is The Chas. Taylor Sons Co. trade name for a complete line of corundum-base (alumina) super-refractories. It will pay you to look into the advantages of TAYCOR for similar applications. Contact the Taylor Field Engineer in your area, or write direct for full details.

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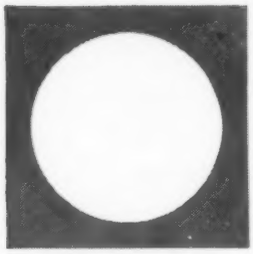
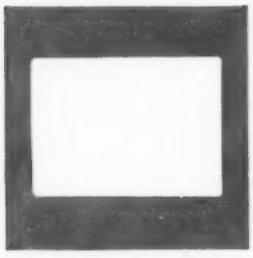
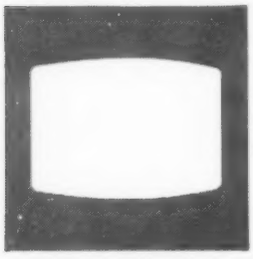


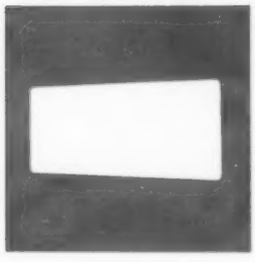
Ball Bearings



Cylindrical Roller Bearings



Spherical Roller Bearings



And now

Tyson **Tapered Roller Bearings***

The broadest product line in the anti-friction field.

SKF—and its field engineers—are now adding Tyson Tapered Roller Bearings to their recommendations.

Constantly working to broaden the SKF line—to make "the right bearing in the right place" a watchword throughout industry, SKF has recently introduced new lines of pillow blocks, styles and sizes of Max type ball bearings, the improved Type "C" Spherical roller bearing.

And *now* SKF offers Tyson Tapered Roller Bearings.

This means that from SKF you get the broadest range of types and sizes of anti-friction bearings *and* the most extensive anti-friction experience.

More today, than ever before, dealing with SKF Field Engineers assures you of the right bearing in the right place. 7848

SKF®

BALL AND ROLLER BEARINGS

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.,
manufacturers of SKF *and* HESS-BRIGHT® *bearings.*

*Manufactured by TYSON BEARING CORP., affiliated with SKF Industries, Inc. as a subsidiary.

Facts on industry's most preferred motor brake

FACT:

Now . . . the only completely **self-adjusting** motor brake on the market

The new Westinghouse type SA (self-adjusting) d-c magnetic brake is the first and only brake on the market to completely eliminate time-consuming brake adjustments. It compensates for lining wear and wheel expansion—and *increases lining life 50%.*

And that's just one cost-cutting feature that makes the new SA the best design available. There are others equally important to your maintenance costs whether your application relates to cranes or hoists, turntables, lift bridges, screw-downs or other similar heavy-duty applications.

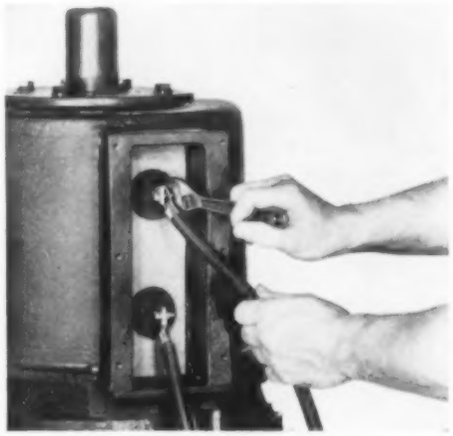
Get all the SA brake facts from your Westinghouse sales engineer—*The Man With The Facts.* J-21895

YOU CAN BE **SURE**...IF IT'S

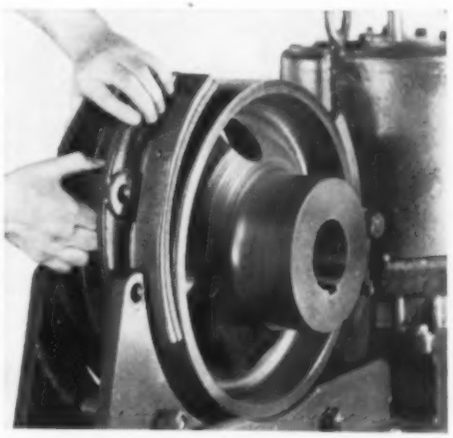
Westinghouse

Maintenance Facts

Dust-tight—weatherproof magnet housing is easily and quickly removed for coil accessibility. Coils can be repaired on the spot—no need to return them for factory repair.



Conduit box is cast integrally with housing —large enough for two-hand workability—can be rotated 120° for a right or left location depending on installation.

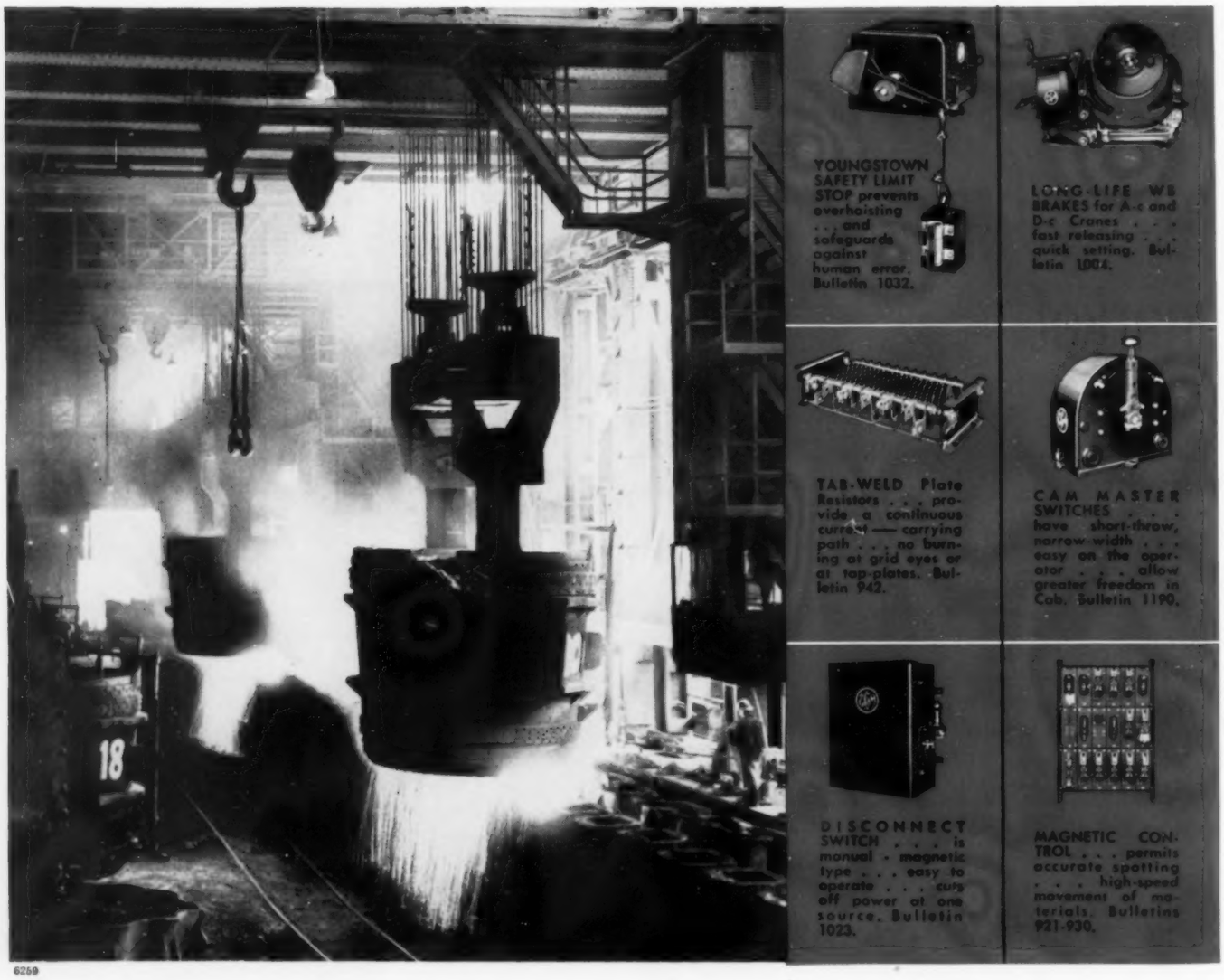


Brake shoes are interchangeable and can be quickly removed for lining replacement. Unique linkage design assures permanent self-alignment both horizontally and vertically with the motor shaft.

Crane Control...engineered to order by EC&M

King size or regular . . . from giant ladle cranes to standard production cranes, EC&M designs the Control equipment specifically for each crane. All control components are engineered and coordinated from the crane data sheet. EC&M uses this method of manufacture to assure precise performance. Operation is smooth . . . response is fast . . . ability to secure accurate inching and quick maneuverability is unsurpassed.

When revamping existing installations or buying new cranes, specify EC&M for complete control . . . control that is engineered to order.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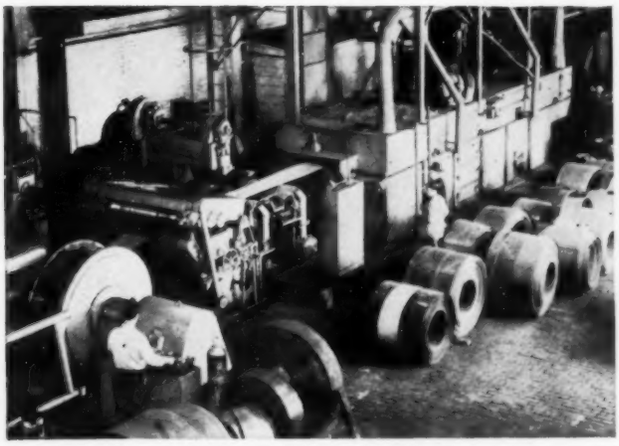
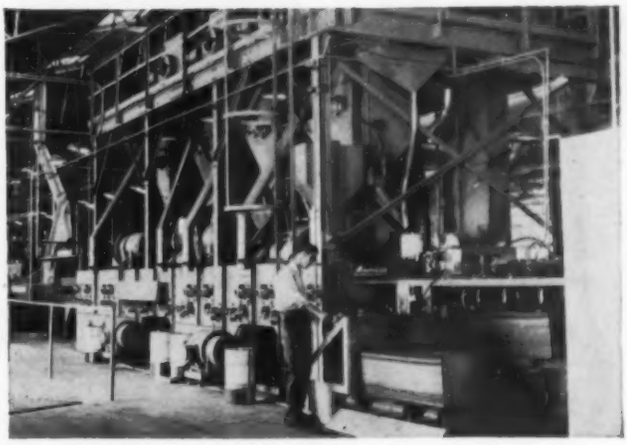
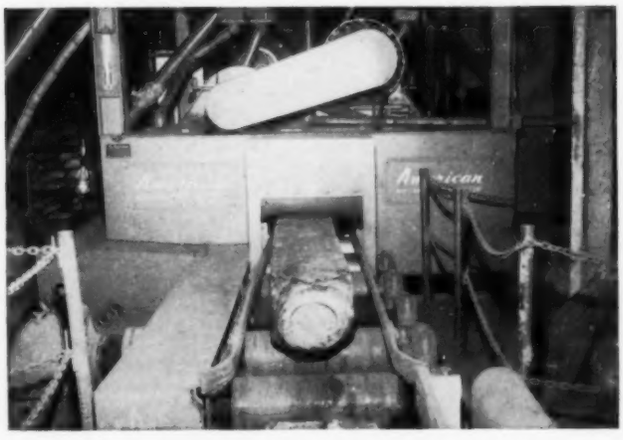


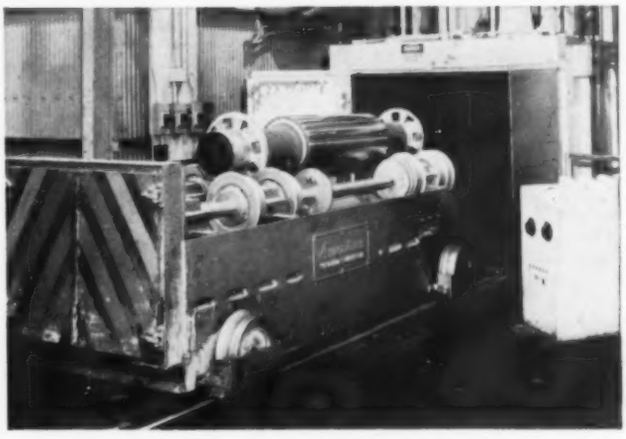
Descaling Strip at Allegheny Ludlum Steel Corp.



Descaling Sheet at Rheem Manufacturing Co.



Descaling Slabs, Billets at Atlas Steel, Ltd.



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More than 60 Wheelabrator installations now descale slabs and billets, continuous carbon strip, sheet steel, bar stock, wire rod and structural steel shapes. They also condition ingot molds and etch mill rolls.

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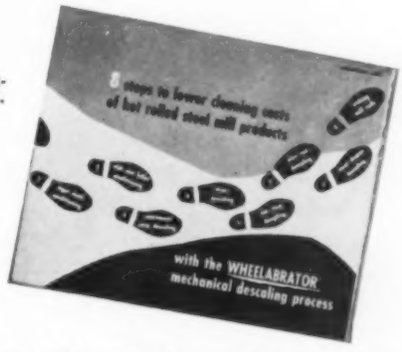

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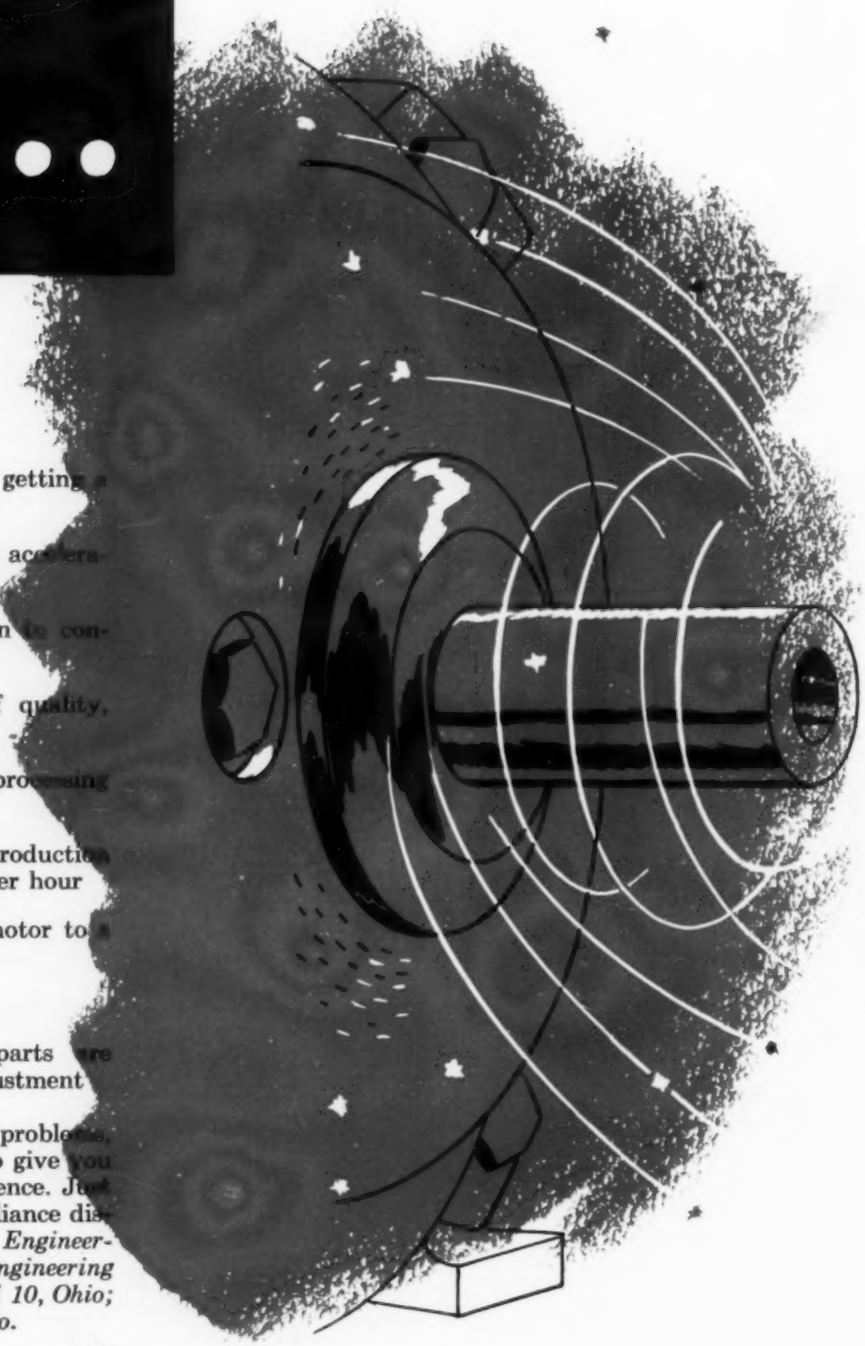

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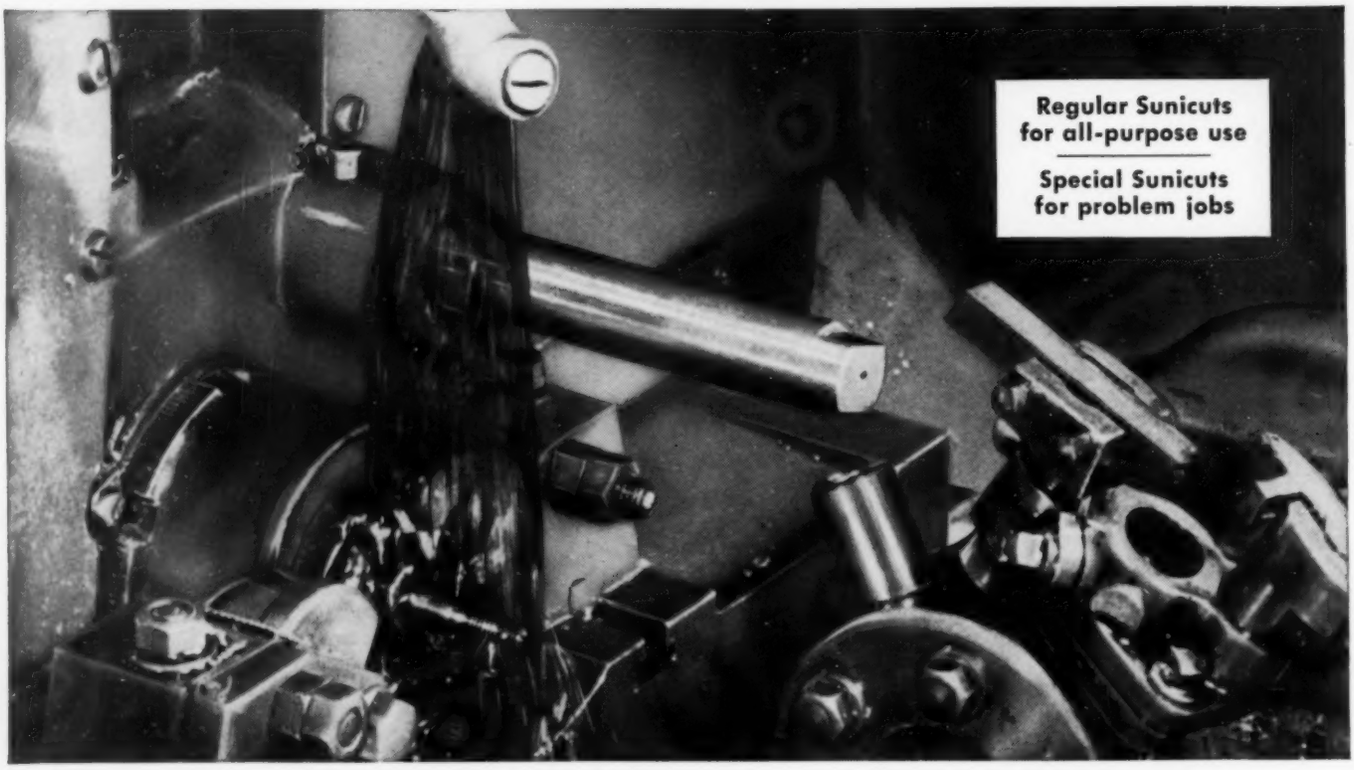

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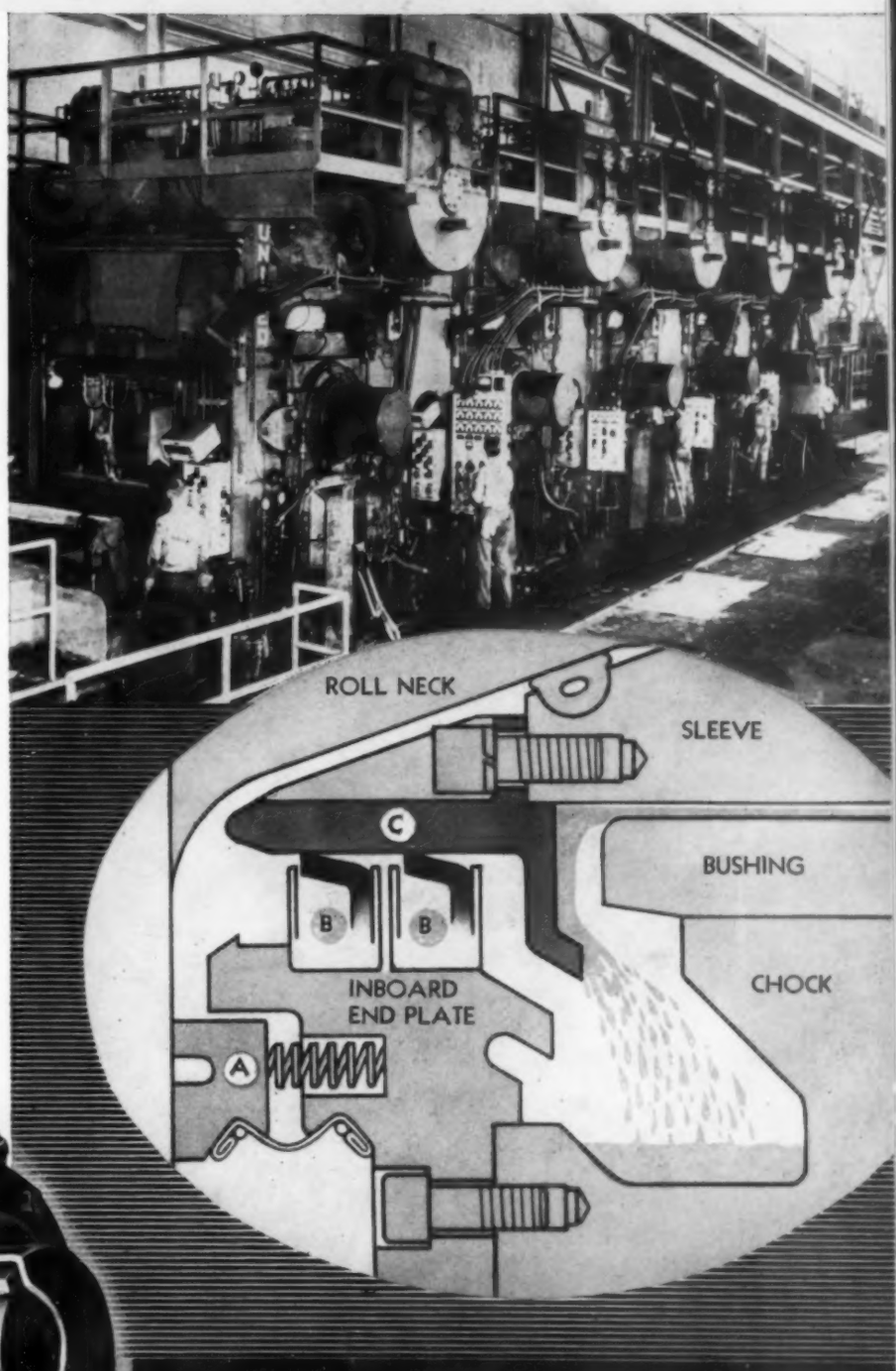

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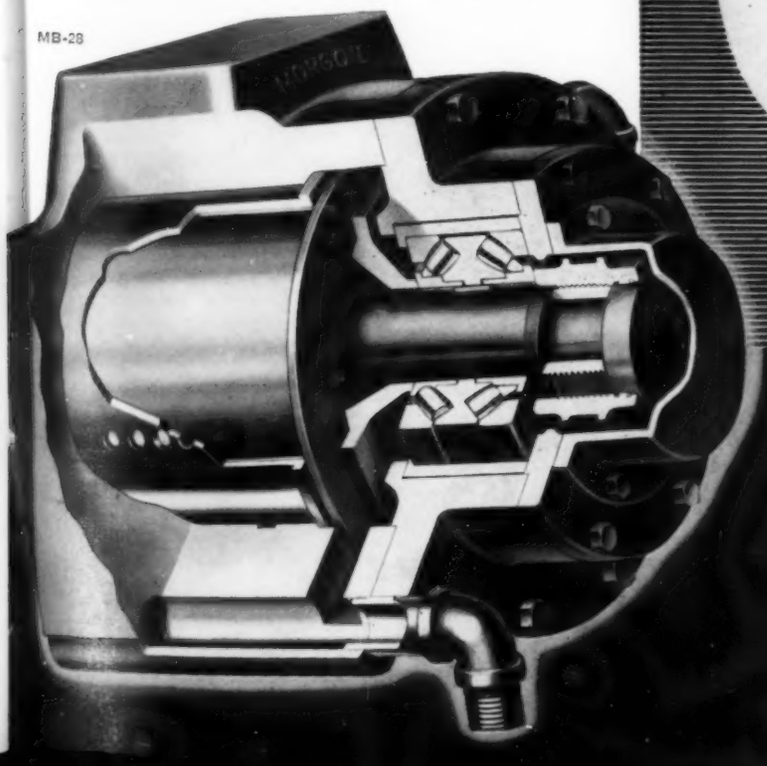

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This is one of three arc furnace transformers built by Allis-Chalmers for The Timken Roller Bearing Company, Canton, Ohio, plant.

The repeated daily short circuits encountered in arc furnace operation require exceptionally rugged transformers that can provide reliability over long periods. That's one reason Allis-Chalmers furnace transformers are chosen for jobs like this. They have served many furnaces for as much as 25 to 30 years.

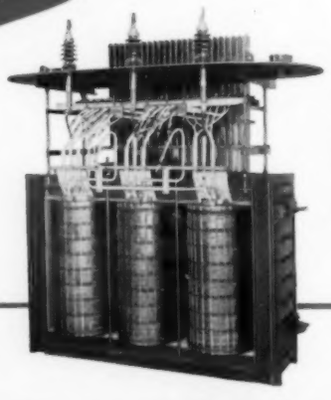
Design Features

Extremely heavy supports brace the coils against short circuit stresses in these transformers. Skillful insulation techniques protect windings from overvoltages due to wide tap range. Some of these transformers have been built with a range of operating voltages of several times the minimum secondary voltage.

The tap changer has specially designed contacts to provide for long life regardless of numerous daily tap changes. The mechanism is located in a separate compartment to facilitate inspection. It can either be motor driven or manually operated or both.

Complete Line of Arc Furnace Equipment

In addition to furnace transformers in ratings up to the largest demanded by expanding arc furnace operation, Allis-Chalmers also builds electrical control, circuit breakers, and auxiliary transformers. Next time you need new or replacement arc furnace electrical equipment, consult the Allis-Chalmers office nearest you or write Allis-Chalmers, Milwaukee 1, Wisconsin. A-4750



Rugged Core and Coil Assembly design is based on Allis-Chalmers more than 45 years' experience building arc furnace transformers. Unit must withstand repeated short circuits.

ALLIS-CHALMERS

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Patent Reviews

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each . . . . patents reviewed cover period March 1, 1955 through March 22, 1955 . . . .

COMBINED SUPERCHARGED BLAST FURNACE AND GAS TURBINE PLANT

▲ U.S. 2,701,443, issued February 8, 1955 to Marcel H. L. Sedille and assigned to Societe Rateau et al, describes a blast furnace plant in which the blast furnace gas is used to operate a gas turbine which supercharges the blast furnace and auxiliaries. The advantage of operating at super-atmospheric pressure is that it permits an increased output for a given size plant.

In Figure 1, the compressor C supplies compressed air for combustion purposes both to the supercharged blast furnace BF and to the combustion chamber Ch, the effluent of the latter being used for operating the turbine T driving the compressors C and Cg and the generator A. Before escaping to atmosphere, the exhaust gases of the turbine T yield part of their heat to the air discharged by the compressor C. The compressed air for the blast furnace BF is further heated by the effluent of the combustion chamber Ch, in the preheater Rv.

The gases issuing at the top of the blast furnace BF at super-atmospheric pressure, contain an important proportion of combustible gases. These gases are burnt in the combustion chamber Ch after having been purified in the dust separator D and after their pressure has been raised, by the compressor Cg, to a value substantially equal to that of the discharge of compressor C. These purified combustible gases are heated, in the heat exchanger E, by the exhaust gases discharged by the blast furnace BF.

As the blast furnace operates at super-atmospheric pressure, a pressure lock is provided at the top of the furnace, in order to allow charging operations without undue loss of pressure. The pressure lock illustrated in Figure 1 is of a conventional type, with a double bell and hopper arrangement. However, even in such devices, gas leakages occur when the bells are actuated, due to the difference in pressure between the shaft and the bell space or intermediate compartment on the one hand, and between the latter and the atmosphere on the other hand.

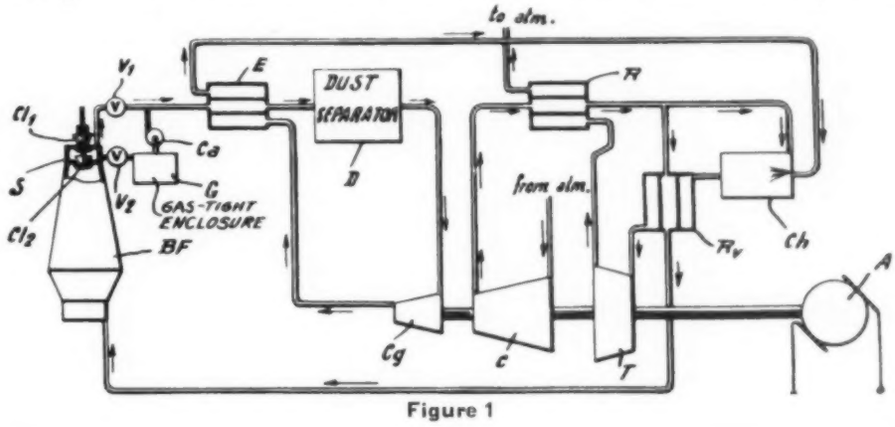


Figure 1

In Figure 1, the bell space S which is a gas-tight compartment, is connected to the flow circuit (E, D, Cg, etc.) through a valve V_1. This valve V_1 is by-passed by a branch circuit including a valve V_2, a gas-tight enclosure G, and an auxiliary compressor Ca discharging into the above flow circuit upstream of E.

During normal operation of the blast furnace, the top bell Cl_1 of the pressure lock is closed while the bottom bell Cl_2 is opened; valve V_1 is opened, whereas valve V_2 is closed. Thus, the gases are allowed to flow from the shaft of the furnace, through the bell space S and the valve V_1, into the external circuit.

When charging is to be effected, the valve V_1 and the bottom bell Cl_2 are closed, and the valve V_2 is opened, thus allowing the gas filling the space S to expand into the enclosure G from which it is sucked up by the auxiliary compressor Ga and discharged into the external circuit at normal operation pressure.

The valve V_2 is then closed, the bell Cl_1 is opened and charging is effected in the ordinary way.

PREPARATION OF FOAMED SLAGS

U.S. 2,702,967, issued March 1, 1955 to Otto K. Vorwerk and assigned to Huttenwerk Rheinhausen A.G.,

describes a method of producing a foamed blast furnace slag which is completely dry.

As shown in Figure 2, the apparatus consists of a tiltable pouring bed or tub 1, which is preferably made of cast iron or cast steel. The bottom of the tub is supported on a pipe 4 which is rigidly connected to the tub and is supported by two bearings 5 to allow tilting of the tub. In the working position the admission end of the tub lies beneath a trough-like ladle 8

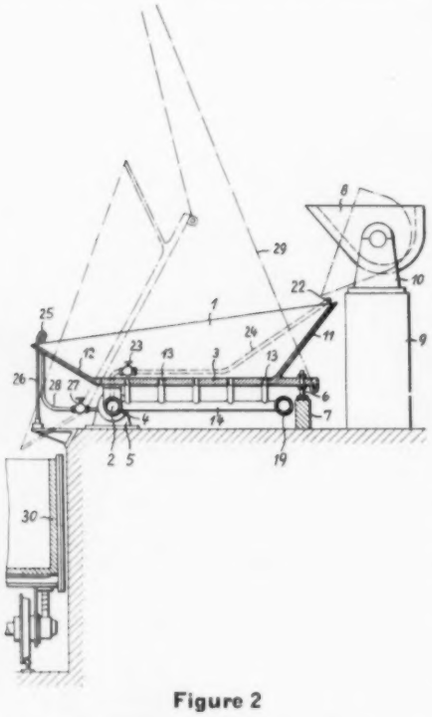


Figure 2

which rests in two bearings 10 on a raised foundation 9. The length of the ladle 8 is about equal to the width of the tub 1. The arrangement is so devised that the ladle in the tipping position (shown dotted) pours into the tub. The cross wall 12 of the tub 1 at the opposite end is also inclined in such a manner that, when the tub is tipped (as shown in dotted lines), it forms a slide for the material to be tipped out of the tub.

In the bottom of the tub are nozzles 13 through which water under pressure is able to pass from below. The nozzles 13 are connected to several pipes 14 lying below the bottom of the tub and proceeding from pipe 4. The end of pipe 4 has connected to it a three way valve which is connected through a pipe and a stuffing box with a supply pipe for the water.

The glowing liquid slag coming from the blast furnace is first charged into the ladle 8, solidified slag portions being held back. Before pouring the slag into the tub 1 enough water is allowed to flow from the supply pipe that the pipes 4, 14, and the nozzles 13 are filled and the bottom 3 is just wetted. By adjusting the supporting screw 6, the tub 1 is given such an inclination by a slight tipping of the tub in clockwise direction that the foaming agent will flow over the pouring-in end of the bottom 3 to a somewhat greater extent than over its other parts. Before pouring in the slag, the walls 11 and 12 are sprayed by means of pipes 22 and 25 so that no slag adheres to them.

Then the ladle 8 is tipped, and the liquid slag flows in a broad flood on to the pouring bed on which it quickly spreads out. At the same time water under pressure is supplied which penetrates from the nozzles 13 from below into the slag layer, partly evaporates, and thereby causes the slag to foam.

Towards the end of the foaming process, the excess water is drained out of the tub. The water flows out of the pores of the foamed slag through the nozzles 13 and the pipes below. The heat content of the slag acts so that moisture remaining behind in the pores of the slag is evaporated and given off as steam. On account of this, there is obtained after a short time a completely dry foam slag of high value which can be transported without further treatment. This is effected simply by tipping the tub into the position shown in dotted lines in Figure 2, whereby foam slag slides over the inclined wall 12 into a wagon 30.

LIQUID FUEL FIRED OPEN HEARTH FURNACES

U.S. 2,704,660, issued March 22, 1955 to Franz Barter and assigned to Maerz Industrie-Ofenbau A.G., describes certain improvements in oil-fired open hearth furnaces, which increase the luminosity of the flame by increasing the amount of thermal cracking of the fuel.

In conventional practice, only a small part of the fuel is cracked because the air flows in the same direction as the jet of fuel and around it as it leaves the burner and is immediately sucked into it, thereby burning the fuel very rapidly. In the present invention, on the other hand, the desired cracking of the fuel is promoted since the air for combustion is fed separately into the furnace space and is mixed with the jet with natural energy (instead of by suction) over a longer course as the jet travels, thus mixing gradually or in a retarded way.

As shown in Figures 3 and 4, inside the end wall 2 there are vertical air shafts 6 and 7 which are positioned

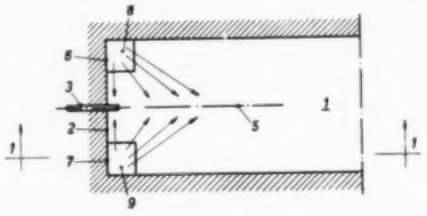


Figure 3

on either side of the burner (or burners). The air for combustion after being heated in the checkers, is fed through the air shafts in the form of two air streams 8 and 9 rising vertically. These air streams first rise on both sides of the burner 3 owing

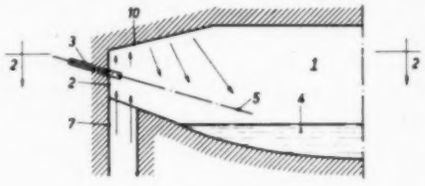


Figure 4

to their natural energy and encounter the roof portion 10 which is inclined forwardly as shown, and follow the direction shown by the arrows. Thus, the air mingles with the fuel jet over a comparatively long course, producing a long and luminous flame.

STOCK LINE RECORDERS

U.S. 2,704,401, issued March 22, 1955 to Albert Mohr, Jr. and John P. Grilli, and assigned to John Mohr and Sons, describes an apparatus which provides a continuous indication and a permanent record of the variation of the burden level in a blast furnace.

In Figure 5, normal operation of the system is initiated by a push-button, which causes a rod-lowering motor 23 to be continuously energized, as well as a rod height recorder, subject only to failure of line current. In the event of line current failure, the try rod 11 is automatically raised to its uppermost position so that it will not be buried by new charges introduced into the furnace. In normal operation, the full energization of the motor is sufficient with the help of the weight of the try rod to lift a counterweight

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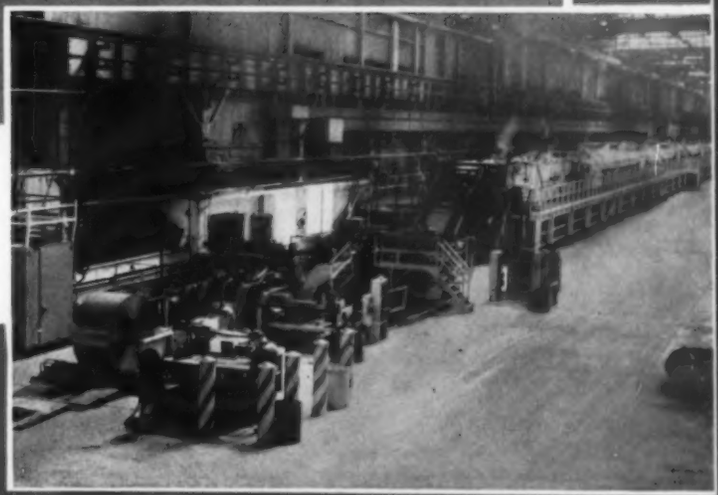

MESTA HIGH-SPEED CONTINUOUS PICKLING LINES WITH TRIMMERS, UP-COILERS AND MESTA-THOMSON FLASH WELDERS

Designers and Builders of Complete Steel Plants

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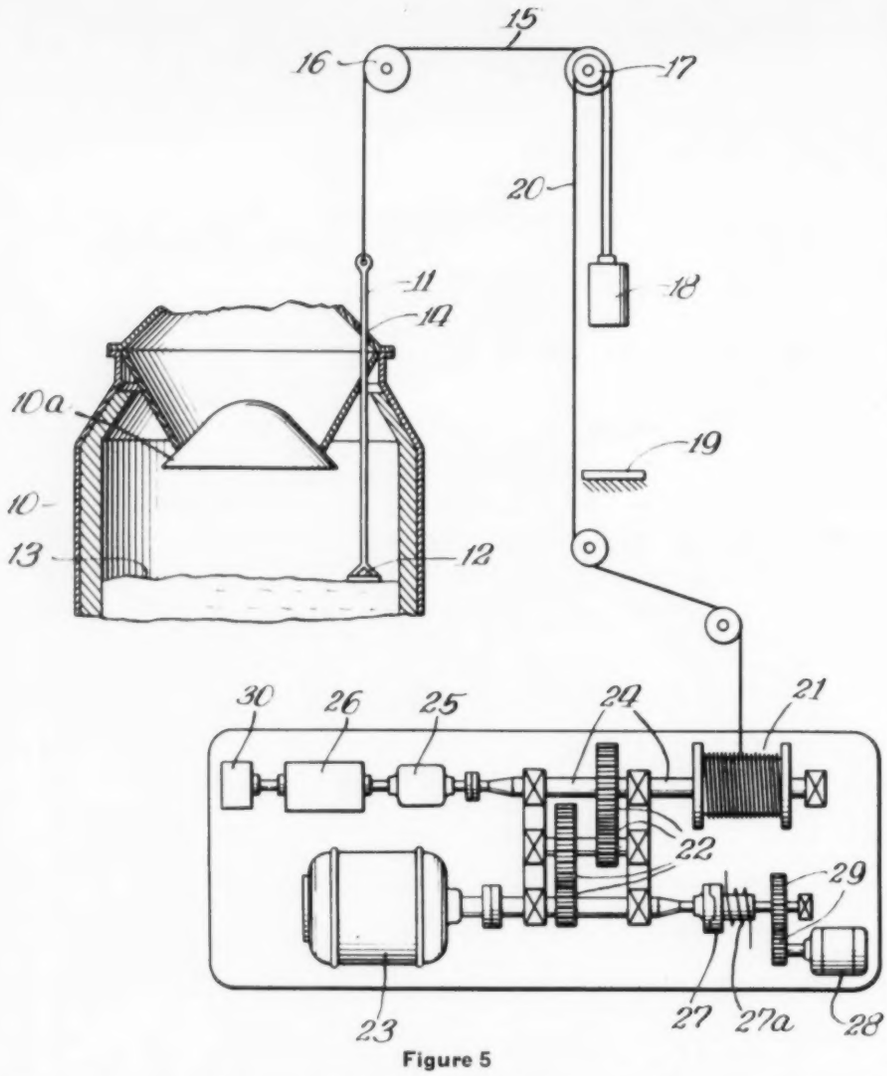

Figure 5

18 and lower the rod. However, when the rod is supported by the burden, the motor alone cannot lower it further, and thus the rod follows the surface level of the burden. Also during normal operation, a second recorder shows the rate of rise or fall of the rod. When a charging operation is to occur, lifting of the try rod to its uppermost position is brought about by a reduction in the energization of the motor such that the counterweight 18 overcomes both it and the weight of the try rod. This reduction is initiated either by push-button or by automatic means controlled by the charging mechanism.

PRODUCTION OF LOW-CARBON ALLOY STEELS

In U.S. 2,704,247, issued March 15, 1955 to William G. Connor, and assigned to Allegheny Ludlum Steel Corp., a method of producing low carbon (0.025 per cent or less) alloy steels in an electric furnace is described. The object of the invention is to speed up the delivery of heat to the melt, in order to reduce the time required for the process and thereby minimize carbon pick-up from the furnace electrodes.

The initial charge of selected scrap steel, lime, limestone, mill scale or iron ore, is delivered to the furnace and is melted down as usual. After the charge has been melted and refined to a carbon content below 0.020 per cent and a phosphorus content of 0.010 per cent or less, the power to the furnace is shut off and the slag removed. Aluminum pigs are then delivered onto the bare surface of the melt. Alloying additions are then made, and the melt is then blown with oxygen in an amount sufficient to fully react with the aluminum, thereby providing sufficient heat to melt and incorporate the alloying constituents in the melt. The heat release is very rapid, thereby saving a substantial amount of time.

CONTINUOUSLY GALVANIZING WITH CONTROL OF SPANGLE AND CORROSION

At high speeds, it is difficult to preserve an attractively large spangle or medium or light gage strips when utilizing high purity zinc. In U.S. 2,703,766, issued March 8, 1955 to Obe B. Ellis and Kasimir Oganowski, and assigned to Armco Steel Corp., this problem is solved.

According to the inventors, the lead content of the spelter or zinc employed has a controlling effect on spangle formation at high speeds and short immersion times. It also strongly affects corrosion resistance. The inventors claim that for maximum corrosion resistance, the lead content must be less than 0.30 per cent. This is low for the high-impurity zincs commonly used. On the other hand, to produce spangle dependably in high-speed production, a lead content of at least 0.12 per cent is required. This is too high for commercially pure zincs known as high grade or high grade special. By proper blending of the two types of zinc, the desired results are obtained.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,703,298	3/ 1/55	Process for annealing stainless steel	Robertshaw-Fulton Controls Co.
2,703,550	3/ 8/55	Apparatus for descaling and coating wire	Northwestern Steel & Wire Co.
2,703,685	3/ 8/55	Gripper jaws for expansible mandrel strip coiling reel	United States Steel Corp.
2,703,999	3/15/55	Pilgrim rolling mills	See Fabriks Aktiebolag
2,704,248	3/15/55	Separating ferrous metal from its gangue	Madaras Corp.
2,704,250	3/15/55	Cobalt-base high temperature high-strength alloys	Crucible Steel Co. of America
2,704,610	3/22/55	Cupola charging apparatus	Modern Equipment Co.
2,704,611	3/22/55	Pinch rolls for billet pusher	United States Steel Corp.
2,704,612	3/22/55	Apparatus for lifting a bundle of rods	United States Steel Corp.
2,704,662	3/22/55	Apparatus for the production of sponge iron	Friedrich Kocks

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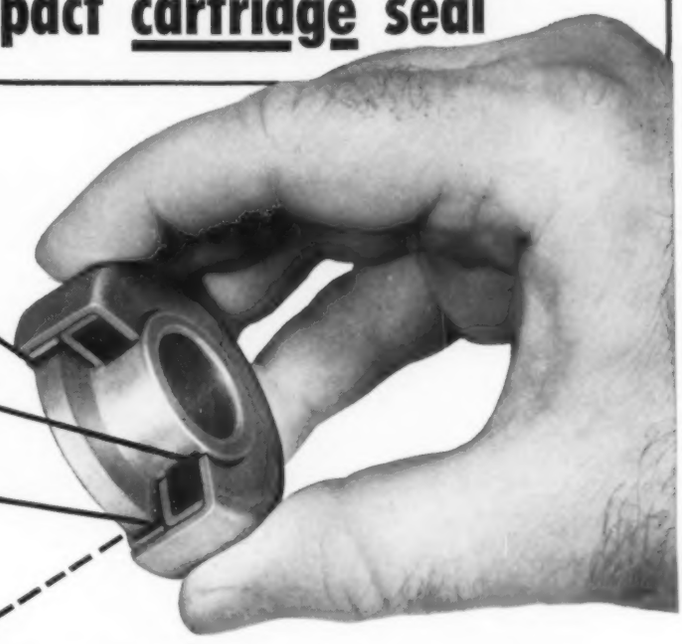
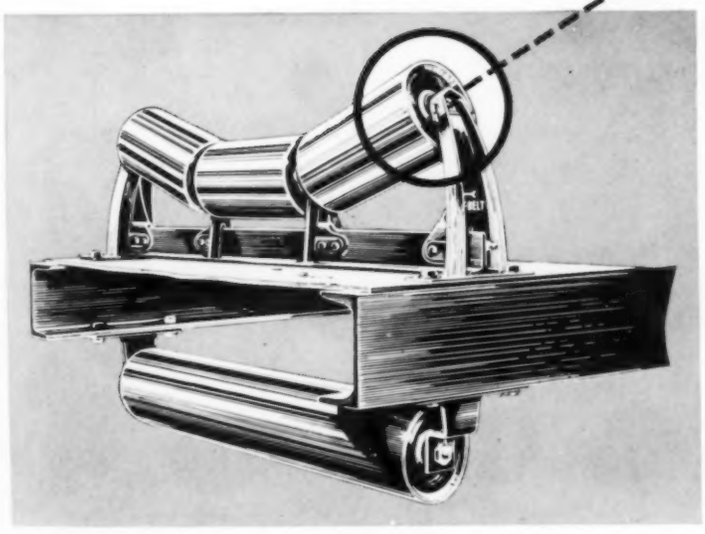


1. Labyrinth seal
2. Contact seal
3. Clearances Grease Filled



THE effectiveness of Link-Belt cartridge grease seals in protecting belt conveyor idler bearings is matched by no other in industry. Besides the normal high efficiency of Link-Belt's labyrinth and contact seals . . . grease within the labyrinth further prevents entry of dirt or other particles. This cartridge (see above cutaway) is one integral unit—no springs, no loose washers . . . no possibility of metal-to-metal contact. From shaft to shell—bearings, fittings, rolls, frames, even hex nuts are designed for long, trouble-free life.

Also important, you can always find the *right* idler in industry's most comprehensive line—over 500 idlers in 34 types, built in a broad range of roll diameters and belt widths with matching return idlers. Ask your Link-Belt sales representative or authorized stock-carrying distributor for 48-page Book 2416, which covers this broad line thoroughly.

LINK-BELT

BELT CONVEYOR IDLERS

LINK-BELT'S superior grease seal is standard throughout industry's most comprehensive idler line

Series 100 Idlers
Continuous service for all but heaviest and coarsest materials.

Series 200 Idlers
Continuous service for heaviest and coarsest materials.

Series 400 Idlers
Continuous service for maximum volume per lineal foot of belt.

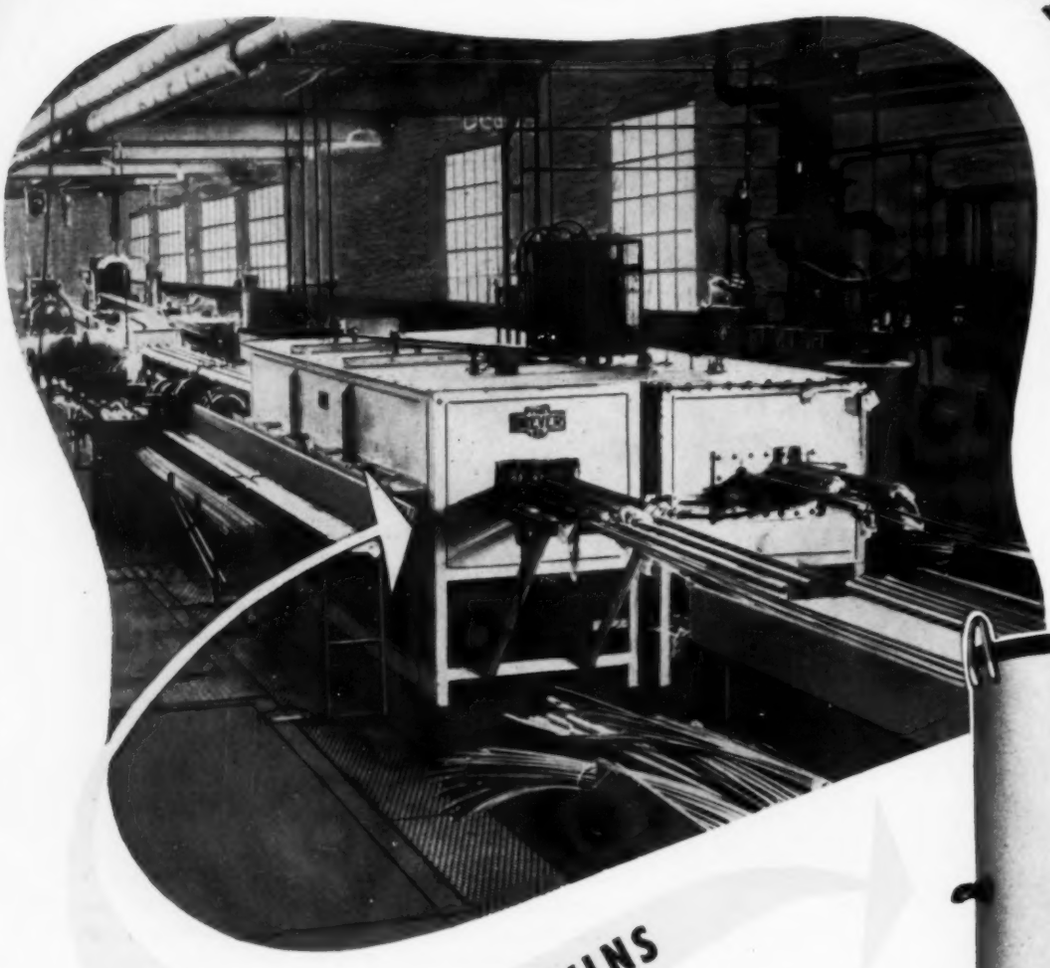
Series 500 Idlers
For greater volume than series 100 at maximum economy.

Series 600 Idlers
For grain and similar materials requiring only light belts.

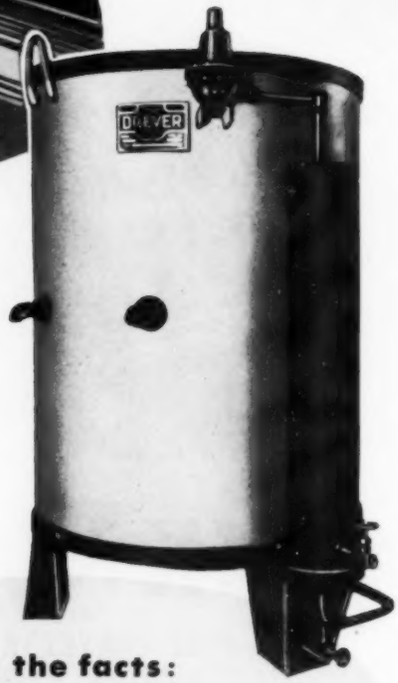
LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,808

bright annealing

OF STAINLESS STEEL TUBING at 2050°F



THESE ARE THE TWINS



The combination of the Drever TUBE TYPE BRIGHT ANNEALING FURNACE with extended water jacketed cooling chamber, and the Drever AMMONIA DISSOCIATOR provides the right way to BRIGHT ANNEAL STAINLESS STEEL AND INCONEL TUBING.

Let our experience help solve your problems. Write or 'phone

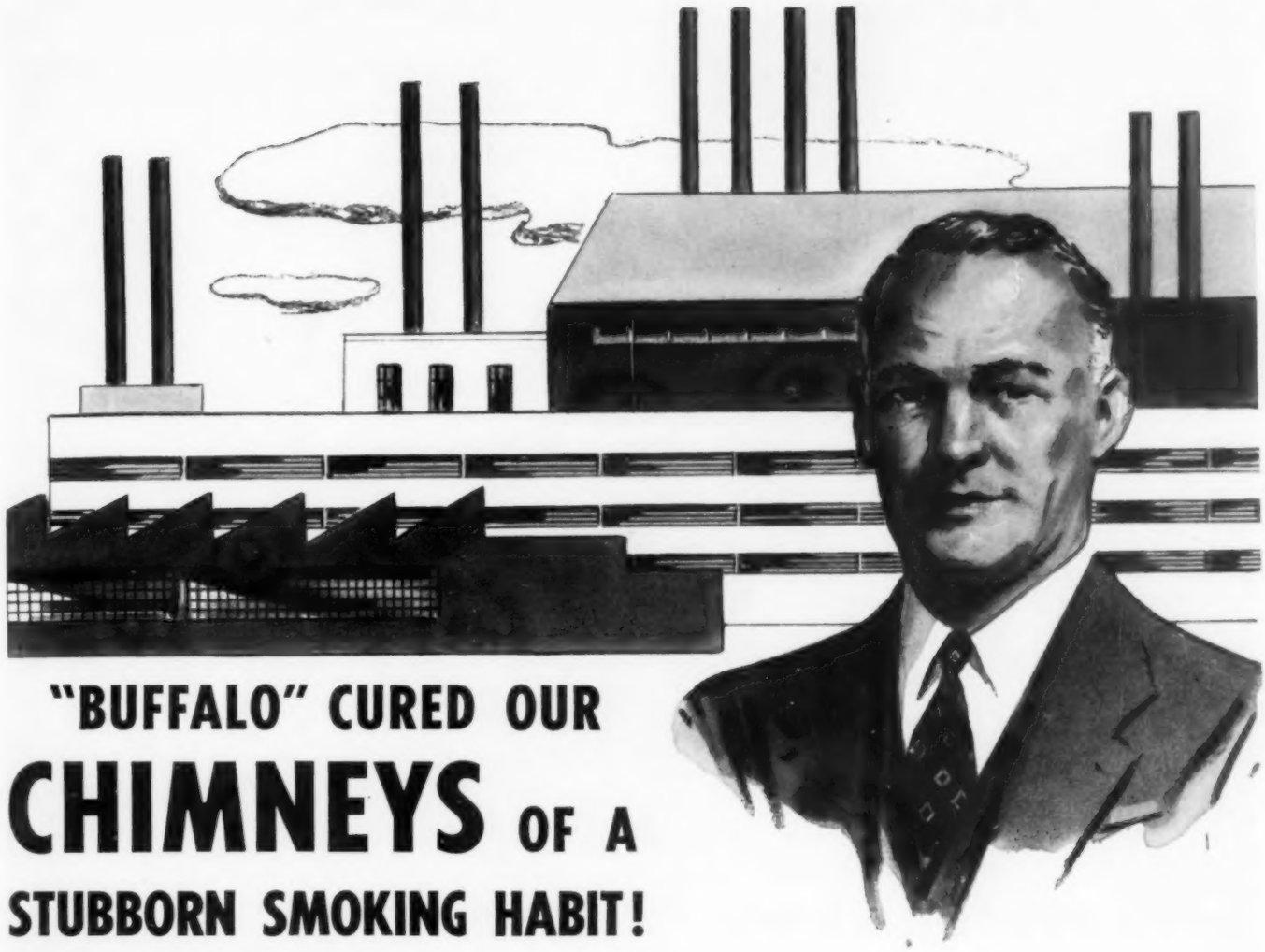
DREVER CO.

RED LION ROAD and PHILMONT AVE. • BETHAYRES, PA.

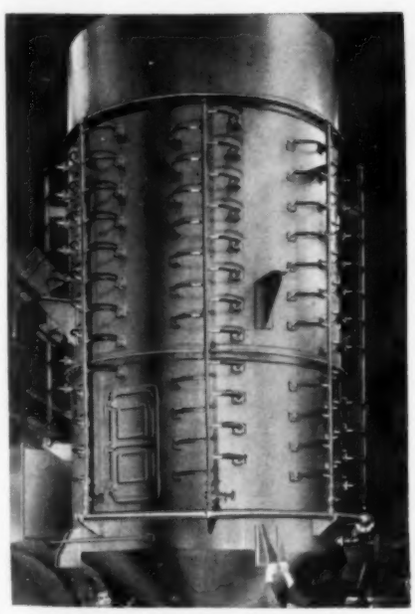
... here are the facts:

1—Fully Annealed
2—Absolutely Bright
3—No scale, oxides or scratches
4—No Carbide Precipitation
5—No pickling required before drawing
6—No pickling after finish anneal
7—Furnace can be gas or electrically heated
8—Capacities up to 2000 lbs./hour
9—Tubing from capillary size to 2½" O.D.

6



"BUFFALO" CURED OUR CHIMNEYS OF A STUBBORN SMOKING HABIT!



"Buffalo" Hydraulic Scrubbing Tower

"We were stumped with a problem of coke breeze discharge. Even after cyclone separation, it was heavily loaded — thick and black. To make matters worse, the contaminant was too abrasive and hot for ordinary equipment to handle! Then we talked to a "Buffalo" engineer. He recommended a unit "Buffalo" just recently developed — a Hydraulic Scrubbing Tower. It cleans by wet centrifugal scrubbing. The effects of heat and severe abrasion are overcome. It doesn't clog — needs very little attention. And its collection efficiency is so high that our stack discharge is harmless and almost colorless. When you consider the improved 'neighbor relations' and the simplicity and economy of operation, our "Buffalo" Hydraulic Scrubbing Towers have paid for themselves many times over."

KNOW-HOW PLUS EQUIPMENT FOR YOUR AIR CLEANING PROBLEMS!

"Buffalo" units and "Buffalo" experience cover the entire range of today's specialized air cleaning applications. Why not call on these facilities for the best results on *your* problem — for the famous "Q" Factor* Performance that plants everywhere are enjoying.

**The "Q" Factor — The built-in Quality which provides trouble-free satisfaction and long life.*

"Buffalo"

BUFFALO FORGE COMPANY

173 MORTIMER STREET BUFFALO, NEW YORK

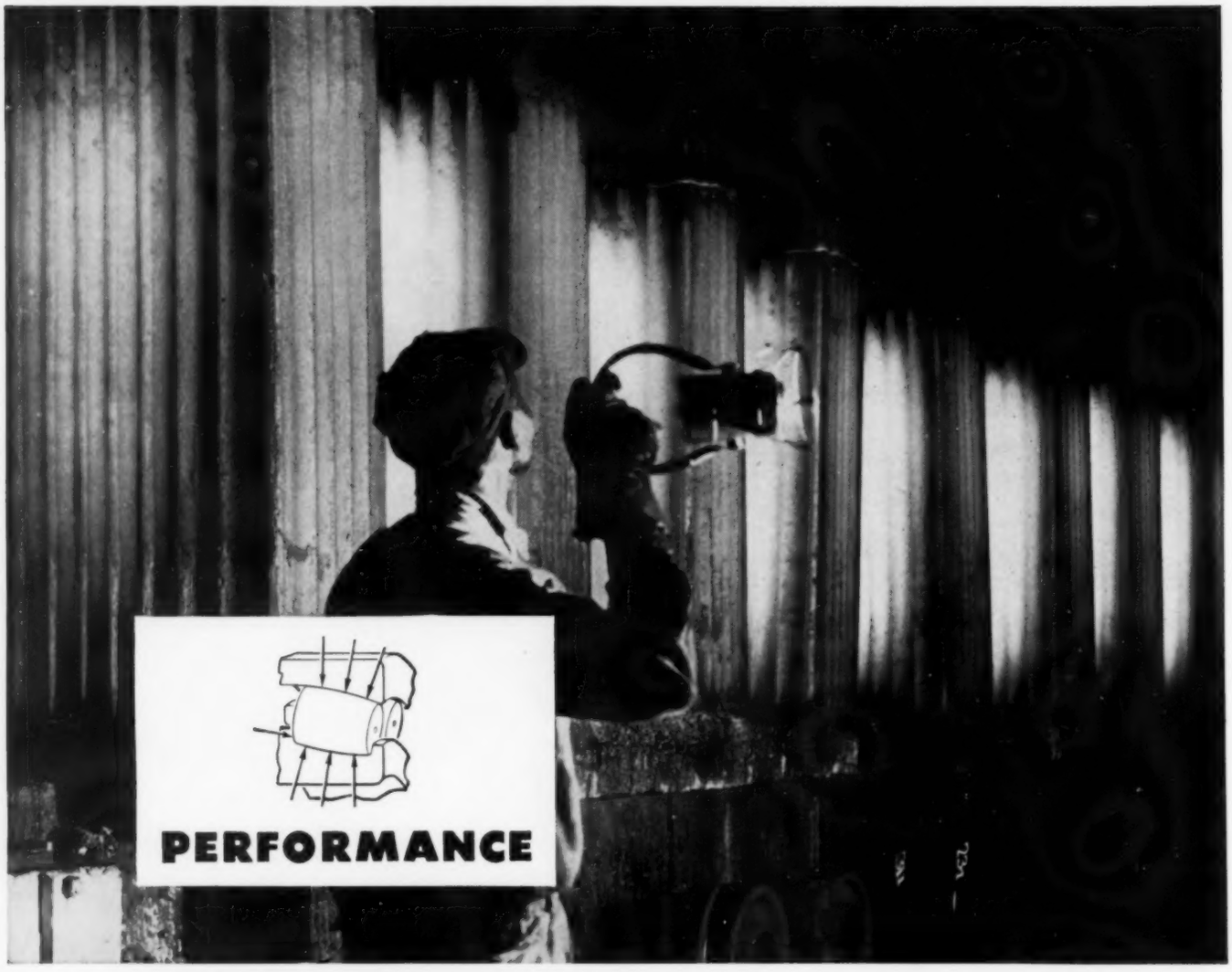
PUBLISHERS OF "FAN ENGINEERING" HANDBOOK

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

Sales Representatives in all Principal Cities

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

IN THE STEEL INDUSTRY, TORRINGTON BEARINGS *are used on work rolls, back-up rolls and many auxiliary applications such as drives, pinion stands, coilers and ingot cars.*



TORRINGTON Spherical Roller Bearings

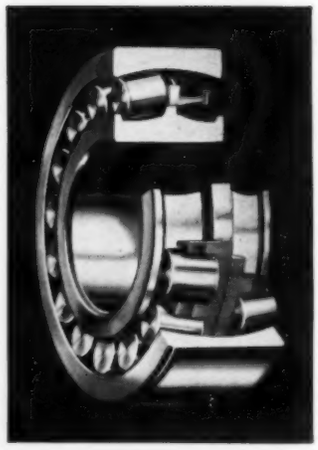
are manufactured with accurate geometrical conformity between races and rollers for ultimate capacity and performance

Because conformity factors are uniformly high, rollers can operate with a minimum of friction and carry greater loads for a longer time.

There are other good reasons why TORRINGTON SPHERICAL ROLLER BEARINGS can guarantee superior performance. Races and rollers are precision ground to a high surface finish from the finest quality electric furnace steel available.

An integral center flange between the inner raceways gives positive radial and thrust stability against continuous high-speed, high-load conditions. Fully machined, cast-bronze, land-riding cages—one for each path of rollers—allow thorough lubrication, reduce wear and lengthen bearing life.

Specify dependable, rugged TORRINGTON SPHERICAL ROLLER BEARINGS in your equipment. They're available with either straight or tapered bore for shaft or adapter mounting.



THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.

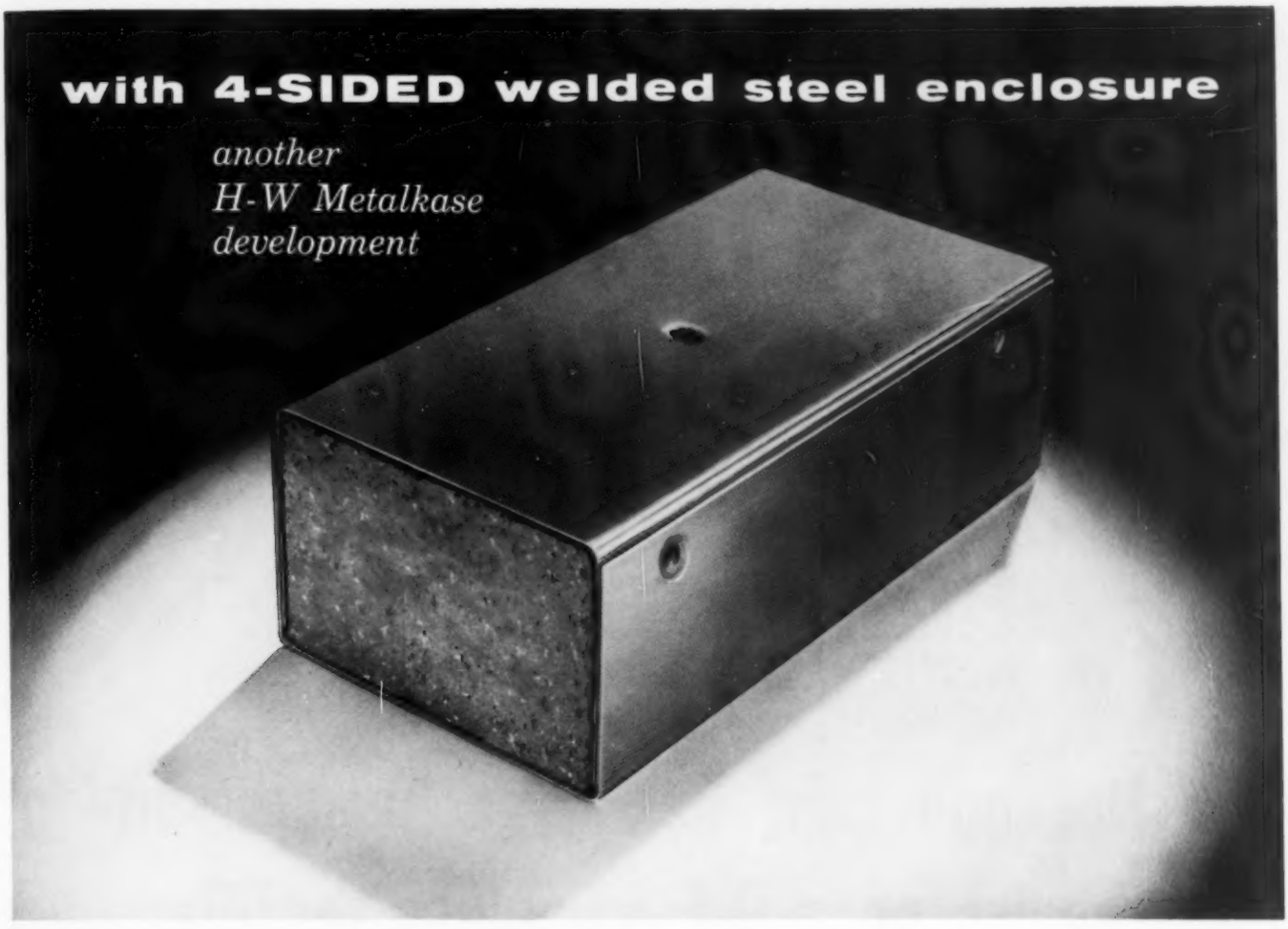
District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON SPHERICAL ROLLER BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers

with 4-SIDED welded steel enclosure

another
H-W Metalkase
development



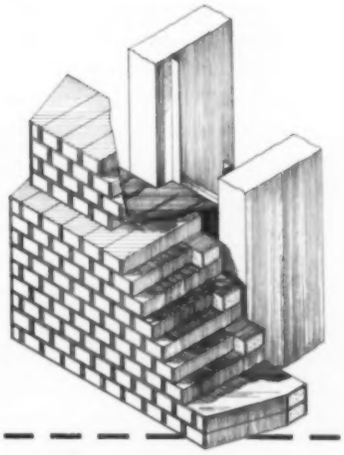
HARBISON-WALKER

metalkase

steel-encased, chemically-bonded basic refractory

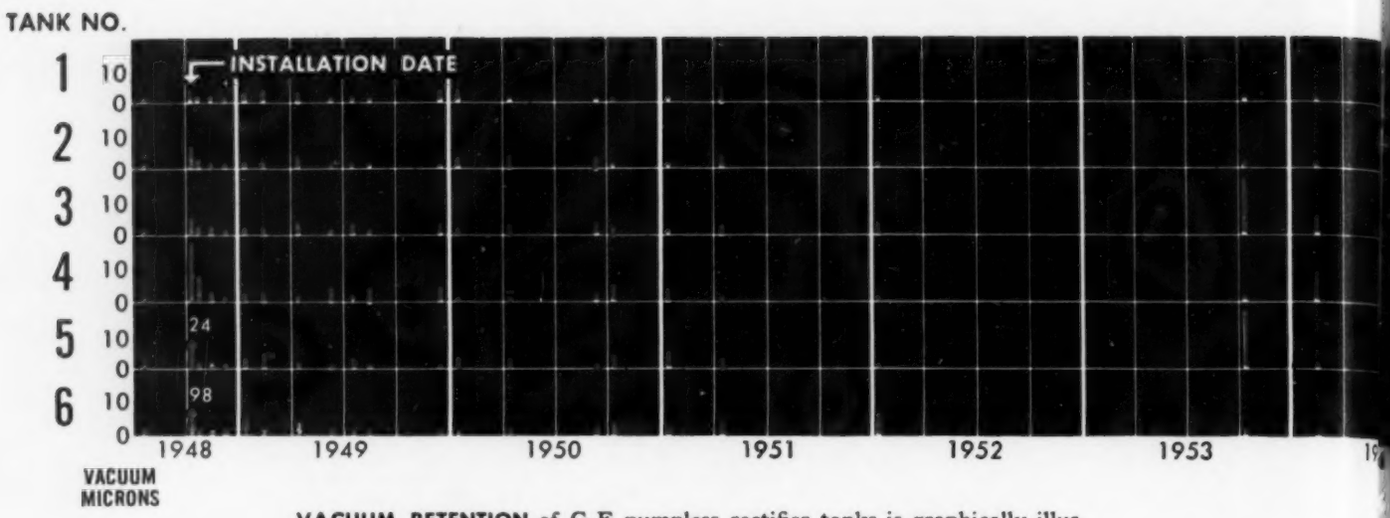
Since the time of the Maccallum invention, more than forty years ago, the original metal-encased basic brick introduced by Harbison-Walker has been manufactured with many noteworthy improvements.

METALKASE, tried and proved in its newest form, is completely enclosed in 22 gauge steel on all four contact sides. The magnesite-chrome refractory rigidly controlled for highest quality is fully formed under great pressure before it is encased. Firm adherence of the welded steel casing to the refractory is assured by the tight grip of the indentation.



Typical section of open-hearth furnace front wall built of METALKASE. For maximum stability steel plates are used at intervals of two to four courses vertically. These are tack-welded to steel bars which in turn extend behind the buckstay and are free to move vertically.

HARBISON-WALKER REFRACTORIES COMPANY
AND SUBSIDIARIES
® World's Largest Producer of Refractories
General Offices: Pittsburgh 22, Pa.



VACUUM RETENTION of G-E pumpless rectifier tanks is graphically illustrated here. None of these six tanks, installed almost seven years ago at the Buffalo plant of the Wickwire Spencer Steel Division of the Colorado Fuel and Iron Corporation, has ever required maintenance. This endurance test is conclusive proof that the G-E pumpless tank is an outstanding performer.

Not one cent has ever been spent for repairs on a G-E pumpless rectifier tank

Since 1948—when the first General Electric pumpless rectifier unit was installed—not a single customer anywhere in the country has paid out a penny for vacuum tank repair. And this is only a start. G-E engineers estimate a much longer life for this equipment. Here's why:

"PERMANENTLY-SEALED" TANKS, manufactured under almost antiseptic conditions, eliminate the need for a pumping system. This, in turn, eliminates such problems as mercury migration between tanks and the possibility of shutdown due to vacuum-system failure.

SUPERIOR MANUFACTURING AND TESTING methods have made this exclusive sealed-tank design possible. Tanks are assembled in a special air-conditioned room, then baked, pumped-down and sealed to assure the best possible vacuum. To check the possibility of even the most minute leak, tanks are pumped in a helium atmosphere and the exhaust is examined by a mass spectrometer leak detector capable of detecting one part of helium in 100,000 parts of normal air.

FACTORY RECONDITIONING of tanks, should it be necessary, is a relatively inexpensive process and relieves you of tank maintenance problems. The tank is reconditioned under the same controlled factory conditions described above and returned ready for more years of service. You can operate with a spare tank during reconditioning.

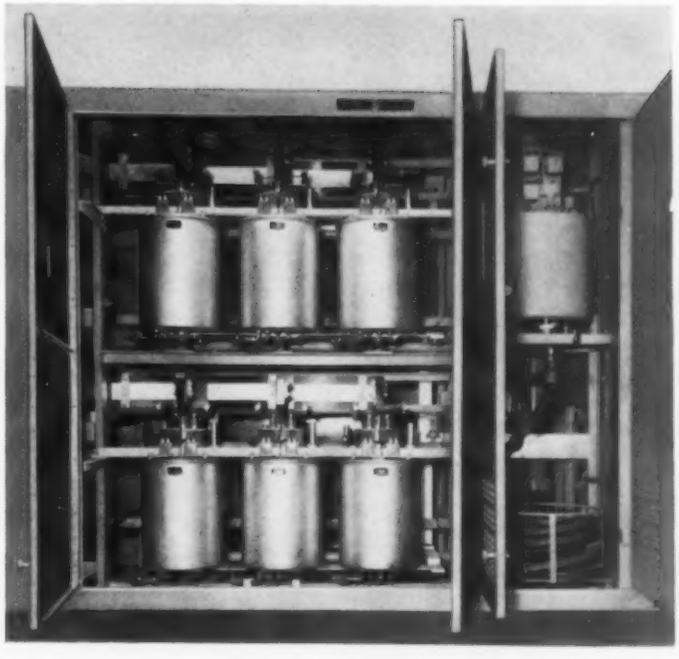
ADD TO THIS the highly efficient operation of mercury-arc conversion and you'll find that G-E pumpless rectifiers are the most economical way to get d-c power in the 750-kw range and above. For the whole story, contact your nearest G-E Apparatus Sales Representative or write for bulletin GEA-5689. General Electric Company, Schenectady 5, New York. 524-2

Progress Is Our Most Important Product

GENERAL ELECTRIC

ASSEMBLY ROOM for pumpless-rectifier tanks is clean, air-conditioned to help prevent contamination. After assembly, testing with mass spectrometer leak detector assures that tanks are free from even the most minute leaks.

LONG LIFE AND LOW MAINTENANCE are the payoff when these tanks are put into service. The six-tank rectifier compartment shown here is furnished with transformer and associated a-c and d-c switchgear—a completely metal-enclosed d-c substation which requires a minimum of floor space.



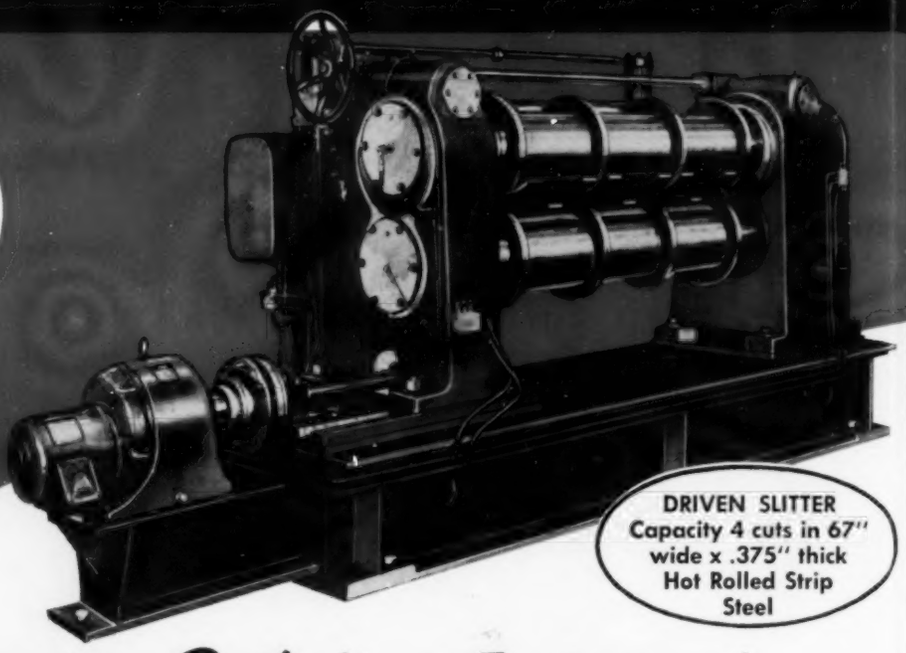
GENERAL ELECTRIC

"YOUNGSTOWN"

has the correct answer to your

Slitting Problem

Whether it is .002" Brass, Copper, Aluminum, or 3/8" Steel Plate — your requirements are exactly met.



DRIVEN SLITTER
Capacity 4 cuts in 67" wide x .375" thick Hot Rolled Strip Steel

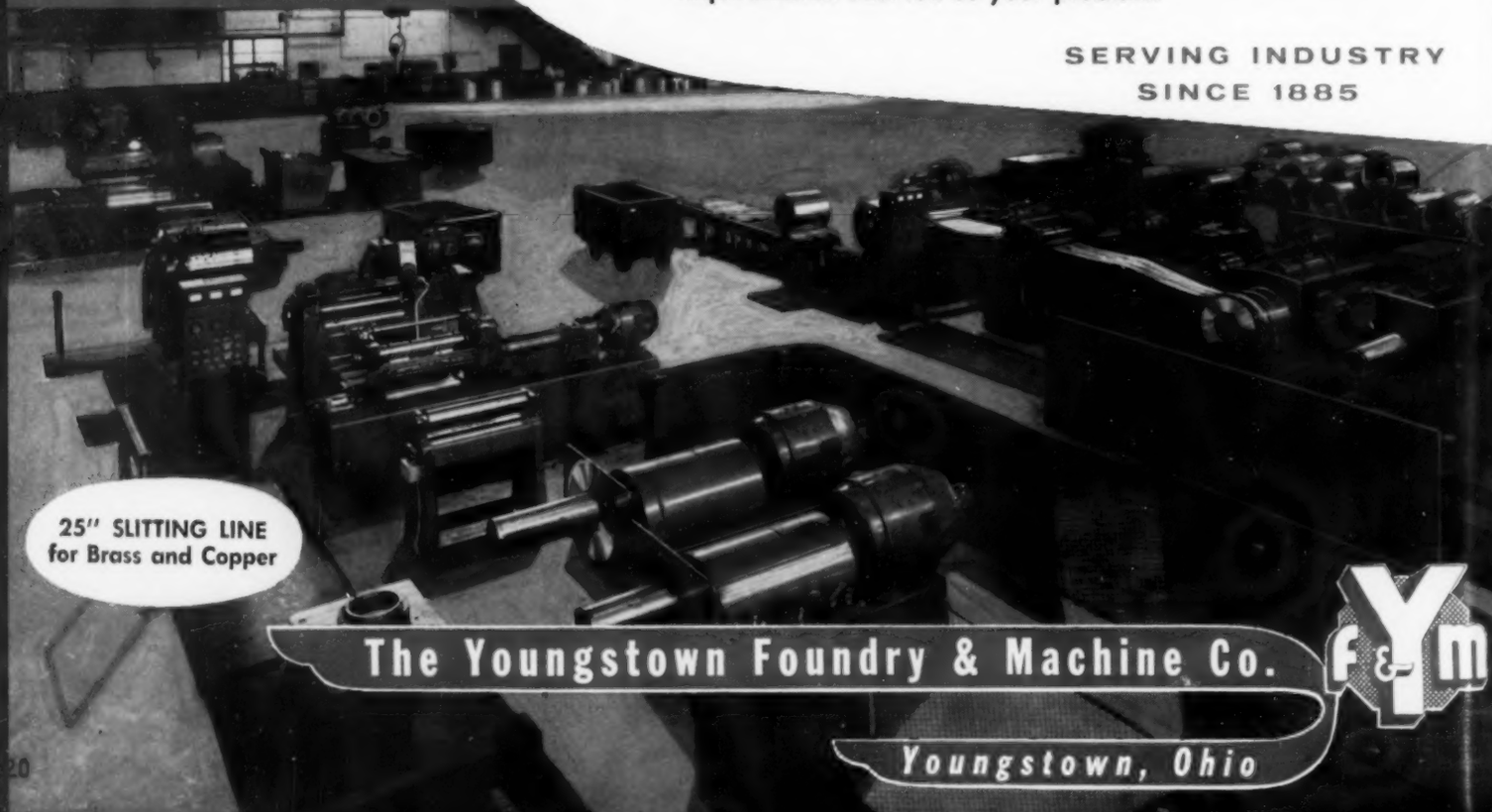
- SLITTERS AND SLITTING LINES
- PAY OFF REELS
- TAKE UP REELS
- UP CUT SHEARS
- UP COILERS
- UNCOILERS
- COIL CARRIAGES
- SCRAP BALLERS

and other Strip Mill Machinery

Precision Built Lines Engineered to Your Needs and Specifications

Savings are substantial when you "slit your own" and more so with equipment built exactly right for the job. Whether you slit non-ferrous or ferrous metals — light or heavy—thin or thick strip—it will pay you to investigate "Youngstown" slitting lines before you buy. Seventy years of experience is back of the designing, engineering and building of "YF&M" slitters and auxiliary equipment. Many installations for leading producers, fabricators and warehouses, offer proof of dependable, economical, profitable operation . . . evidence of our ability to supply the 100% correct answer to satisfy your individual requirements. Just tell us your problem!

SERVING INDUSTRY
SINCE 1885

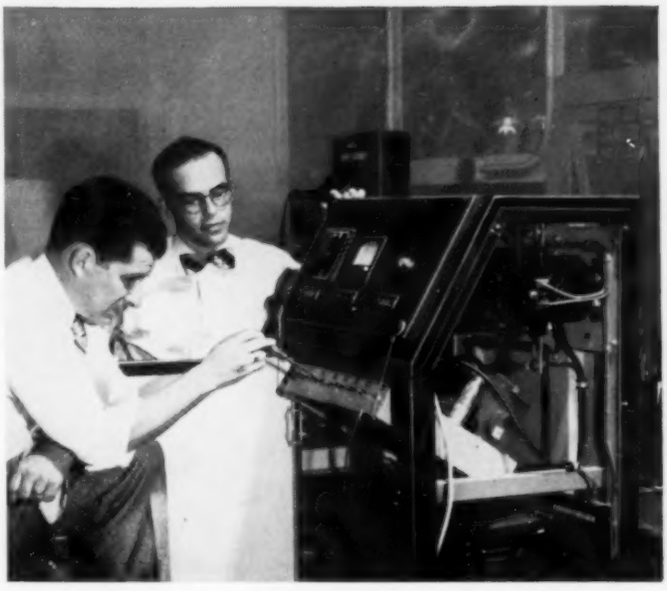


25" SLITTING LINE for Brass and Copper

The Youngstown Foundry & Machine Co.

Y F&M

Youngstown, Ohio



Endurance and Operating Characteristics Tests at New Koppers Lab help develop better couplings

At the Koppers Metal Products Division, engineers and technicians are at work in a new Mechanical Development Laboratory. Their purpose—to maintain Koppers leadership by improving present products and developing new products and adaptations.

Modern coupling development is an important phase of the laboratory's operations. Present day couplings as well as models of advanced coupling designs undergo actual "load tests" to prove endurance and to study operating characteristics. From this Koppers research and development comes the promise of new, more efficient Fast's Couplings for the future—enabling Koppers to continue to give you the *right* coupling for *any* job.

The new Koppers Mechanical Development Laboratory will benefit all industry. To put these benefits to work directly for you, consult Koppers whenever you have any coupling problem.

New lab studies all Koppers products

Research and testing under way in the new Koppers Development Laboratory includes: Endurance and operating tests for couplings, engine tests for piston and sealing ring endurance and characteristics, new precipitator controls and electrical equipment, pilot-plant tests of gas flow and distribution . . . and many more developments that will keep *all* products of Koppers Metal Products Division the most advanced in their field.

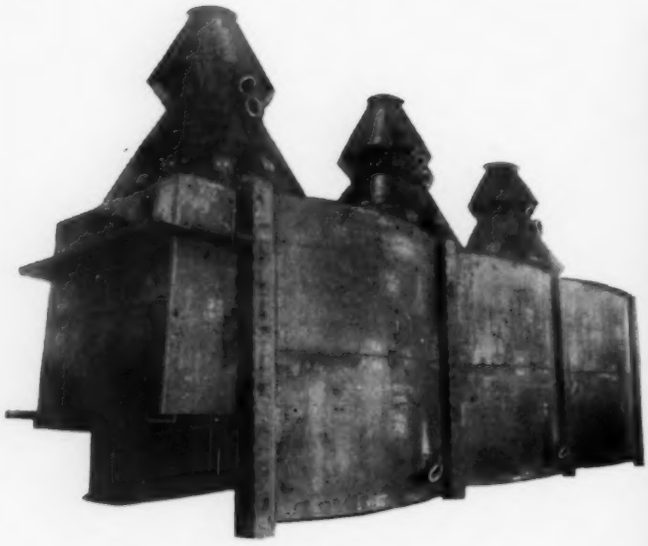
THE ORIGINAL **FAST'S Couplings**

KOPPERS

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC., 217 SCOTT ST., BALTIMORE 3, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Koppers Electrostatic Precipitators, Aeromaster Fans, Gas Apparatus. ***Engineered* Products Sold with *Service***

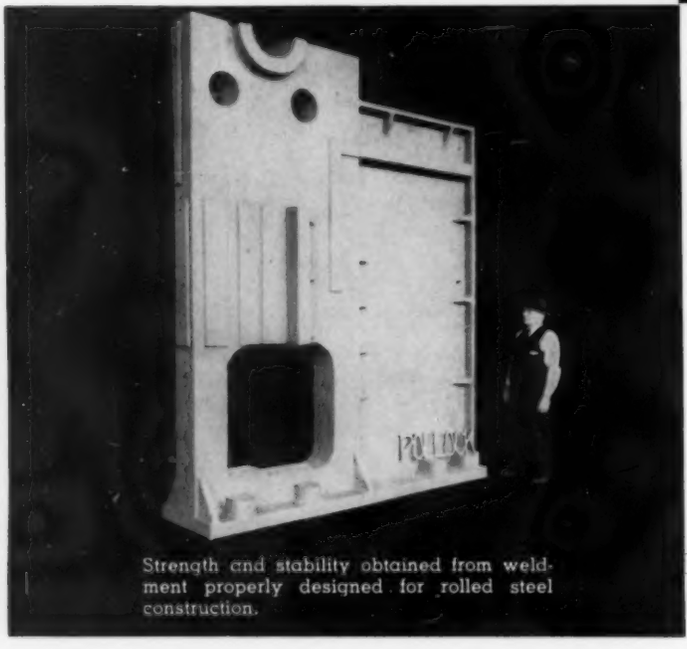
Complete Facilities

for all steel plate fabrication and erection

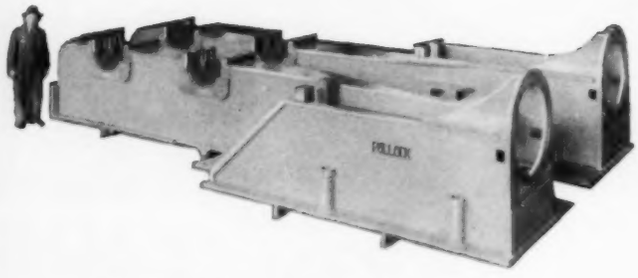


Intricate light gauge steel construction requiring precision fitting.

Complicated pipe connection including carefully fitted hi-carbon liner plates.



Strength and stability obtained from weldment properly designed for rolled steel construction.



Heavy weldment replacing steel casting, making better job and with considerable savings.

BLAST FURNACES • HOT METAL CARS AND LADLES
CINDER AND SLAG CARS • INGOT MOULD CARS
CHARGING BOX CARS • WELDED OPEN HEARTH LADLES

Your steel plate work of all kinds is in safe hands at The William B. Pollock Company. Pollock methods, machines and men have served the steel industry since 1863.

Pollock's modern production techniques and experience help cut your costs on all steel plate work. Precision machines are employed in forming, flame cutting, welding and machining plate from ¼" to 7" thick. If your weldments have finished surfaces or are joined to machined castings, Pollock can do the entire job for you . . . we are prepared to erect in the field the steel we fabricate. Your inquiries are invited.

STEEL PLATE CONSTRUCTION • ENGINEERS • FABRICATORS • ERECTORS

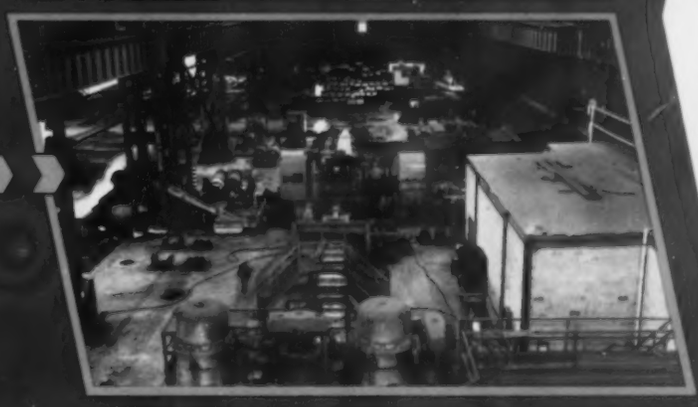
THE WILLIAM B. POLLOCK COMPANY

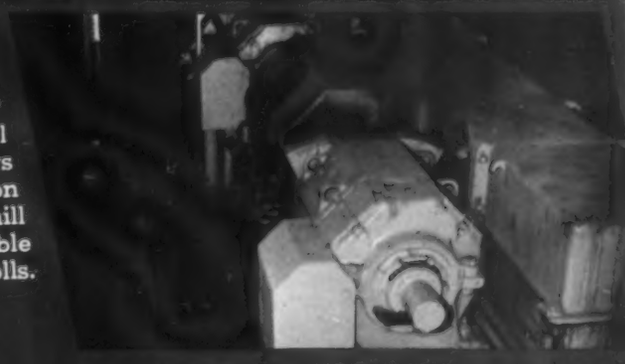
YOUNGSTOWN, *Since 1863* OHIO

operation TSP at Detroit Steel

TSP Trolley Wheels on 30-ton overhead crane.

TSP Bridge Wheels on 30-ton overhead crane.

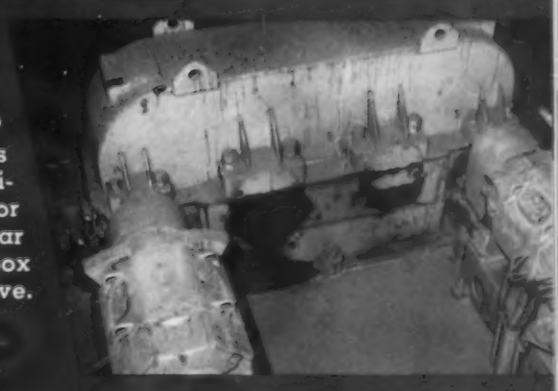




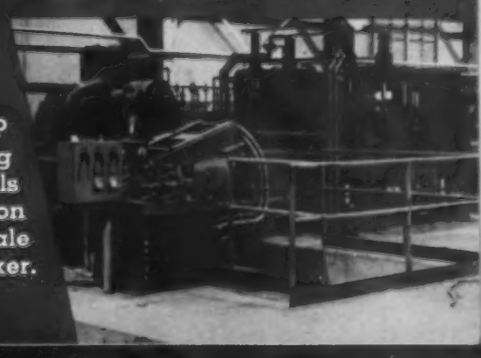
TSP Bevel Gears on mill table rolls.

You'll find "Tool Steel Process" hardened products all over Detroit Steel, Portsmouth Division, Portsmouth, Ohio. These TSP products include gears, rolls, drums, crane wheels, bevel gears, and many other important parts. TSP products are used because service tests in the nation's steel mills have established TSP superiority over any other competitive material previously used. Our long experience in the Steel Industry, our special production facilities, metallurgy and engineering make TSP products the standard of quality—your best investment.

TSP products are hardened by our special process. The file hard surface to full depth of permissible wear gives maximum life. The core, refined for toughness and ductility, gives maximum strength. You receive a positive written guarantee that TSP products will give a longer life in the same service than any other product.



TSP Gears in manipulator gear box drive.



TSP Crimping Rolls on scale breaker.

THE TOOL STEEL GEAR AND PINION CO.
CINCINNATI 16, OHIO, U. S. A.

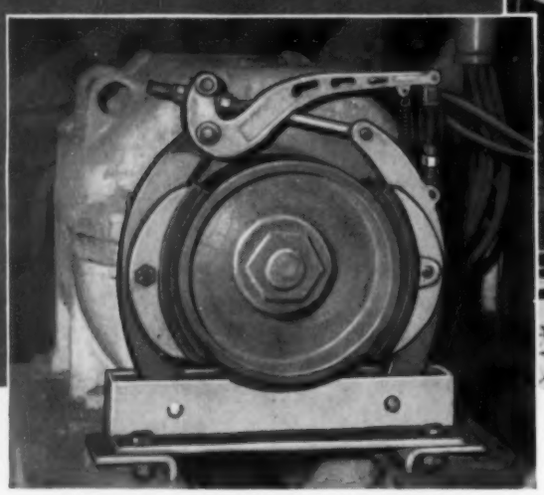
AD No. 1010

The Standard of Quality Since 1909 for Gears • Pinions • Rolls • Wheels and Other Hardened Products

Wagner®

CRANE-BRIDGE BRAKES
...the choice of leaders in industry

World's largest ladle cranes equipped with Wagner Hydraulic Crane Bridge Brakes



Three 450 ton ladle cranes, at Fairless, are equipped with Wagner Type H Hydraulic Crane Bridge Brakes like the one shown at the left.

At U. S. Steel's Fairless Works, Wagner hydraulic crane bridge brakes enable operators to bring the world's largest ladle cranes—450 tons each—to safe smooth stops as easily as if they were braking an automobile.

Plenty of braking power is available at all times from two Wagner 18″ x 8″ type H brakes on each of the three cranes. Operators work both brakes simultaneously with a single control cylinder mounted in the crane cab. Operators do not tire before the end of a working day because the foot pressure necessary at any time is well within the capability of the average worker.

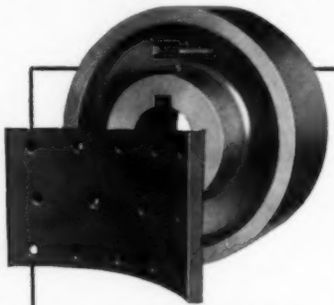
These exclusive Wagner features improve efficiency, lengthen lining life and reduce maintenance costs:

REMOTE CONTROL BLEEDER—Enables operator to bleed hydraulic lines from the cab.

SELF-CENTERING DEVICE—Centers shoes on wheel and prevents brake drag.

ONE-POINT ADJUSTMENT—Makes it easy to keep brakes properly adjusted.

If your cranes are not equipped with Wagner Brakes, we can show you how simple it is to install a modern hydraulic system. Four sizes, with or without parking attachment, cover the field and can handle any crane bridge braking application. Wagner also offers *Powered* Hydraulic Crane Braking for applications where exceptional ease of braking operation is desired. Bulletin IU-40 gives full information—write for your copy today.



Replacement Lining and Brake Wheels

Wagner offers the perfect combination of brake wheel and non-scoring lining for replacement needs. Specially designed for industrial uses, it is available in rolls, blocks, and discs.

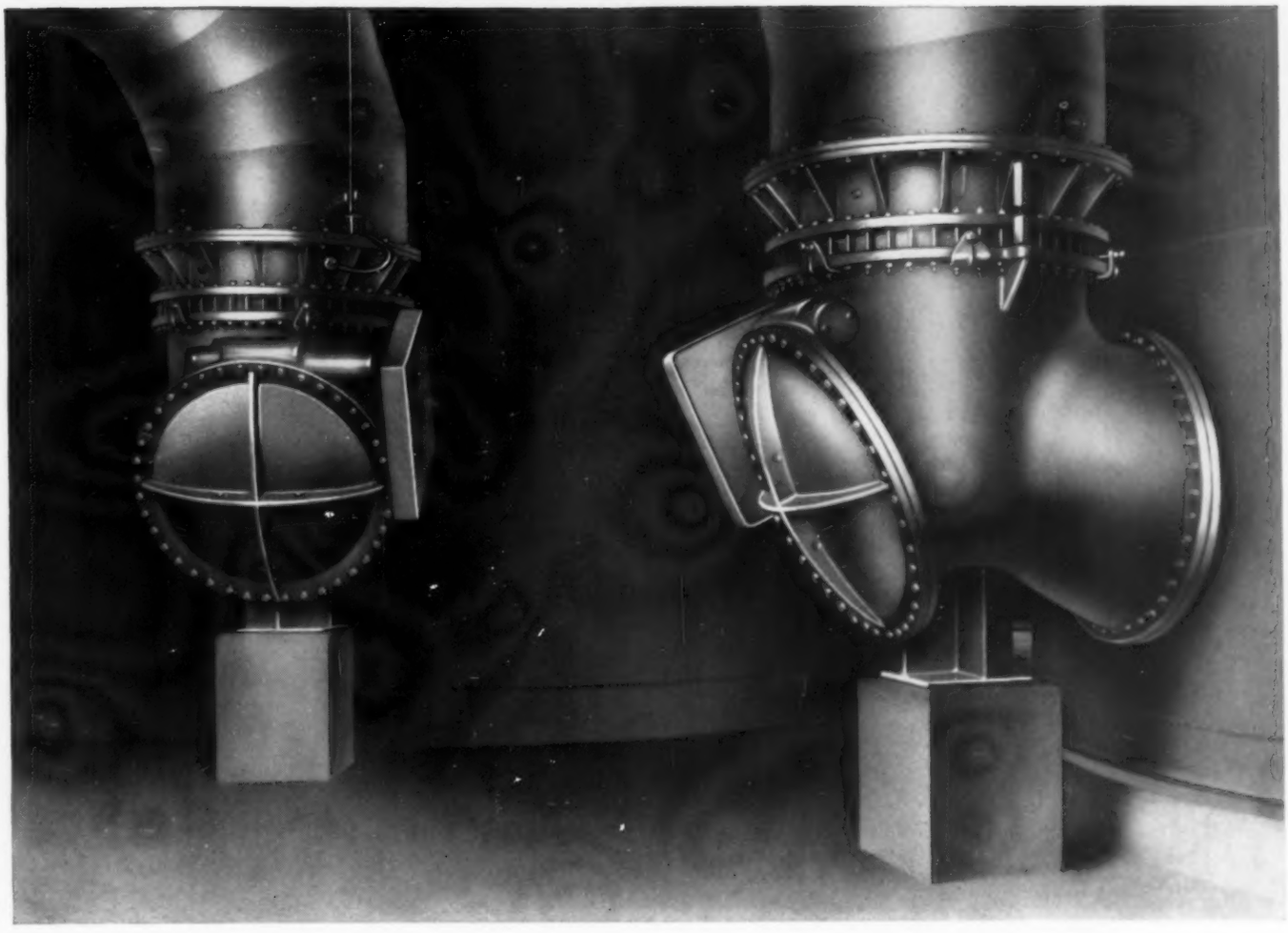
Wagner Electric Corporation EST. 1891

WAGNER ELECTRIC CORPORATION
6483 PLYMOUTH AVE., ST. LOUIS 14, MO., U.S.A.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

ELECTRIC MOTORS
TRANSFORMERS
INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

155-2



622 Freyn-Design Chimney Valves in Service...

No Replacements!

The impressive service record of the Freyn-Design Chimney Valve for hot blast stoves is the best proof of its reliability.

It is a mushroom valve of the angle type, in which a simple, positive counterweight mechanism, passing over dead center, locks the disc in open or closed position. The valve disc opens away from the water-cooled seat and, when in the open position, is out of the path of the stream of hot stack gases.

When the spherically-machined disc is closed, stove blast pressure automatically forces a tight, sure closure. The valve can be cycled in less than 30 seconds, and may be operated manually either at the valve or from a floor stand on the floor above. It can also be provided with a motor or compressed air operator.

Freyn-Design Chimney Valves—in both top and bottom discharge design, with and without cold blast connections—have been proved in 622 installations. None has ever been replaced.

Investigate the long-range reliability and economy of Freyn-Design Chimney Valves for your hot blast stoves. We'll be glad to provide you with complete design and cost information. Write or call today!

KOPPERS

KOPPERS COMPANY, INC.

Freyn Department

Engineering & Construction Division

KOPPERS BUILDING • PITTSBURGH 19 *Associated with* Ashmore, Benson Pease & Co. Ltd., Stockton-on-Tees, ENGLAND; De Lattre & Frouard, Paris, FRANCE

OVERALL GRINDING PERFORMANCE

Faster grinding...

greater accuracy...quicker setup...reduced costs

A Farrel® heavy-duty roll grinder will take heavy cuts for rough grinding or grind a roll to the highest mirror finish. On either type of work there's no faster way to grind a roll. Many automatic features speed and simplify both setup and operation.

Rolls are ground with a perfect surface, free from marks of any kind. Straight, convex or concave contours are ground to exact symmetry and accuracy.

Faster grinding means increased productive capacity of the machine and less labor per roll ground. In addition, the rolls have longer life because the exceptionally smooth and vibration-free action in roll, wheel, and traverse drives means less metal has to come off to clean up a roll in roughing and finishing operations. This is a vital factor in reducing the frequency of roll replacement and consequently the cost of new rolls.

Detailed information about these versatile, cost-cutting roll grinders is available on request.

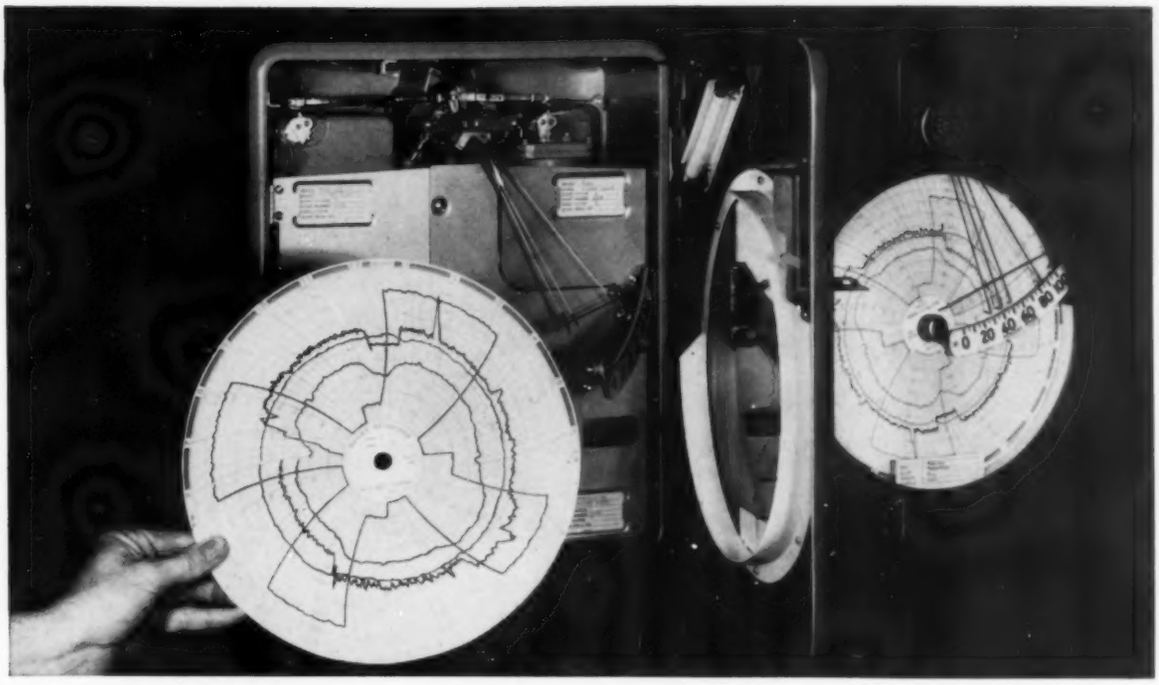
FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT
Plants: Ansonia & Derby, Conn., Buffalo & Rochester, N.Y.
Sales Offices: Ansonia, Buffalo, New York, Akron, Pittsburgh, Chicago, Fayetteville (N.C.), Los Angeles, Houston

FARREL ROLLING MILL MACHINERY

Rolls • Rolling Mills • Rod Mill Tables and Manipulating Equipment • Universal Mill Spindles • Rod Coilers • Gears • Mill Pinions • Pinion Stands • Gear Drives of Any Capacity • Flexible Couplings • Roll Grinding Machines • Roll Calipers.

Farrel-Birmingham®

FB-1018



Faithfully yours –

Clear, Continuous Records without Poisoning . . . on the New Bailey Recorder

★ Faithful chart records of measured variables are the key to a meaningful, dependable analysis of operating trends and conditions. Money spent for more accurate metering, for faster response, is money down the drain—*unless* it's matched with chart records that are equally accurate.

That's why these features of the new Bailey Recorder are important to you:

1. Bailey's exclusive sealed capillary-action inking system maintains continuous flow to the pen tip, and traces sharp, opaque, quick-drying records. "Poisoning" of intersecting records is practically eliminated; no blots or smears during operation or chart changing.

2. Pens are mounted on concentric centers, trace on parallel time arcs only 42/1000" apart. This simplifies analysis of two or more records.

3. Interchangeable plug-in receiver units permit practically limitless record-grouping combinations.

Write for Product Specification E12-5 and actual chart sample. P32-1

ONLY BAILEY OFFERS ALL THESE ADVANTAGES IN A SINGLE RECORDER

- Pre-calibrated plug-in receiver units
- Up to four pneumatic or electronic receivers —or two receivers and two integrators
- Any four variables on one chart—easily read and interpreted
- A full year's ink supply at one loading
- Faster shipment—from stock
- Minimum inventory of parts
- Minimum instrument investment for process cycle expansion or alteration

BAILEY
METER COMPANY
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CLEVELAND 10, OHIO
Controls for Power and Process

BAILEY METERS
Controls for
TEMPERATURE
PRESSURE
GAS ANALYSIS
FLOW · LEVEL
RATIO · DENSITY

Crucible Steel, Midland, Pennsylvania

"Cities Service Heat Prover helps make special steel, saves fuel"

THE CITIES SERVICE HEAT PROVER . . .

Not an instrument that you buy . . . but a service we supply! . . . FREE!

Crucible Steel Company of America is another leading steel company that has found the Cities Service Heat Prover a valuable aid in its furnace operation.

Here's what Crucible has to say about the Heat Prover at its Midland Works, one of several where it is in constant use.

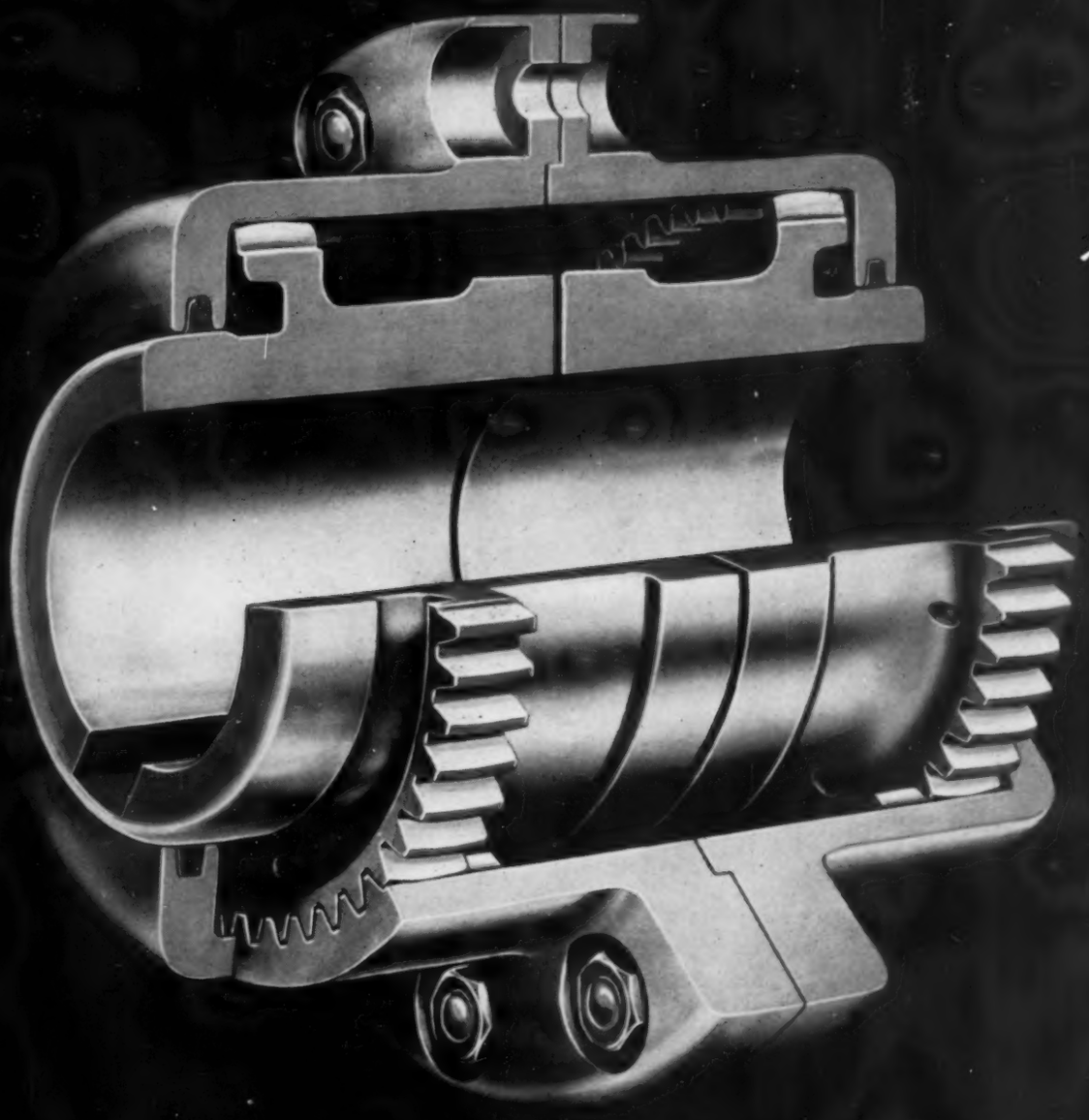
"The Heat Prover has become our standard tool for the setting up and checking of combustion controls on our many furnaces at Midland. It has also helped immensely in setting up special atmospheres for special grades of steel by providing fast and reliable analyses, and has been particularly instrumental in the improvement of fuel economy. Cities Service has kept the Heat Provers in perfect running order and on many occasions has gone out of its way to help us."

You, like Crucible Steel, can achieve better results in *your* furnace operation with the Cities Service Heat Prover. Supplied and maintained free by Cities Service, it offers easy portability, rapid continuous sampling, simultaneous reading of oxygen and combustibles. For more information, talk with a Cities Service Lubrication Engineer. Or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N.Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

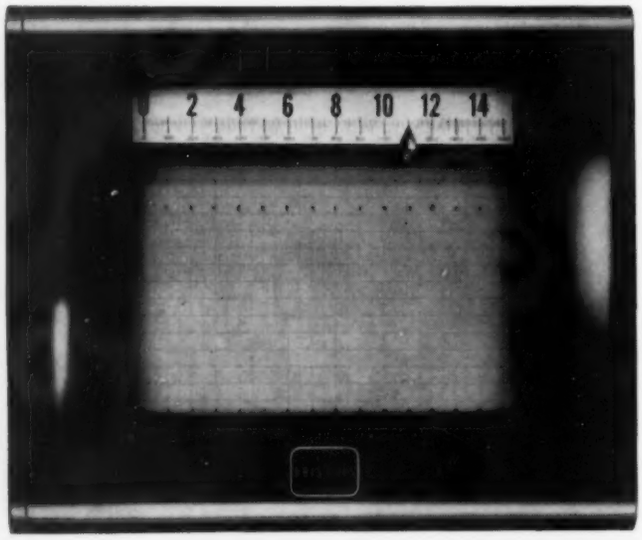
FLEXIBLE COUPLINGS

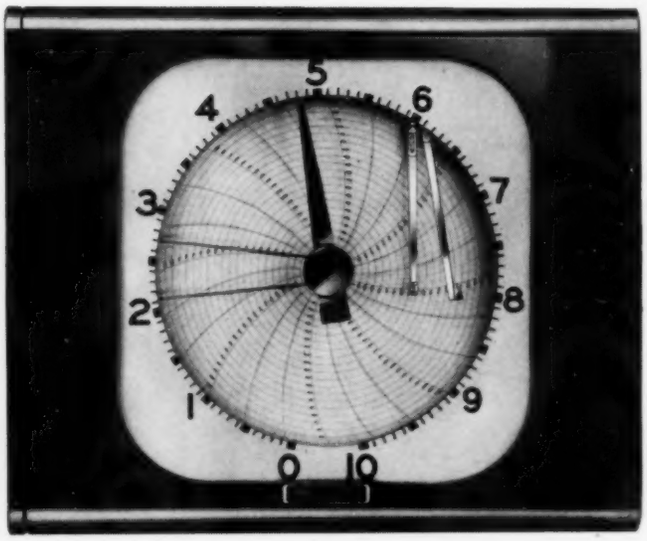
POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

WHAT'S NEW AT BRISTOL...

Three Ways to Better Temperature Control





BRISTOL ELECTRONIC DYNAMASTER® POTENTIOMETERS

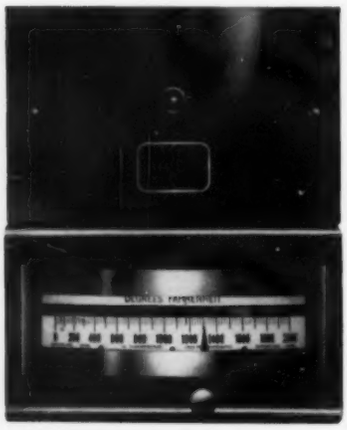
CONTINUOUS STANDARDIZATION WITH NO DRY CELLS: Bristol Dynamaster Potentiometers with No-Batt Continuous Standardization which eliminates need for dry cells. Results: no interruption in operation for standardization, no batteries to replace.

A MODEL FOR EVERY REQUIREMENT: Dynamaster Potentiometers are available as single-pen, two-pen, and multiple-record (up to 24 points) *strip-chart* instruments and as *round-chart* instruments.

ELECTRIC AND PNEUMATIC CONTROLLERS. Both strip- and round-chart instruments are made in a very wide variety of controllers that meet every furnace and oven control requirement, including the following in a great many forms:

Electric Control — on-off, average position, proportional input, 3-position, proportioning, proportional with automatic reset, and time-program.

Pneumatic Control — on-off, proportional, and proportional with reset.



FREE-VANE® ELECTRONIC PYROMETER CONTROLLERS

- **Very minute changes in temperature** at the control point (less than 0.003″ on scale) closes or opens the Thyratron-operated relay with positive trigger action.
- **New high-torque, rugged millivoltmeter measuring mechanism** gives greater accuracy — Alnico V magnet — and a sensitivity of 15 ohms per millivolt.
- **Separate control units are plug-in.**
- **Wide variety of models** — available in thermocouple and radiation pyrometer controllers in ranges up to 4000°F for L, H, LH, LOH, and LNH control and for L and H with proportional input control.

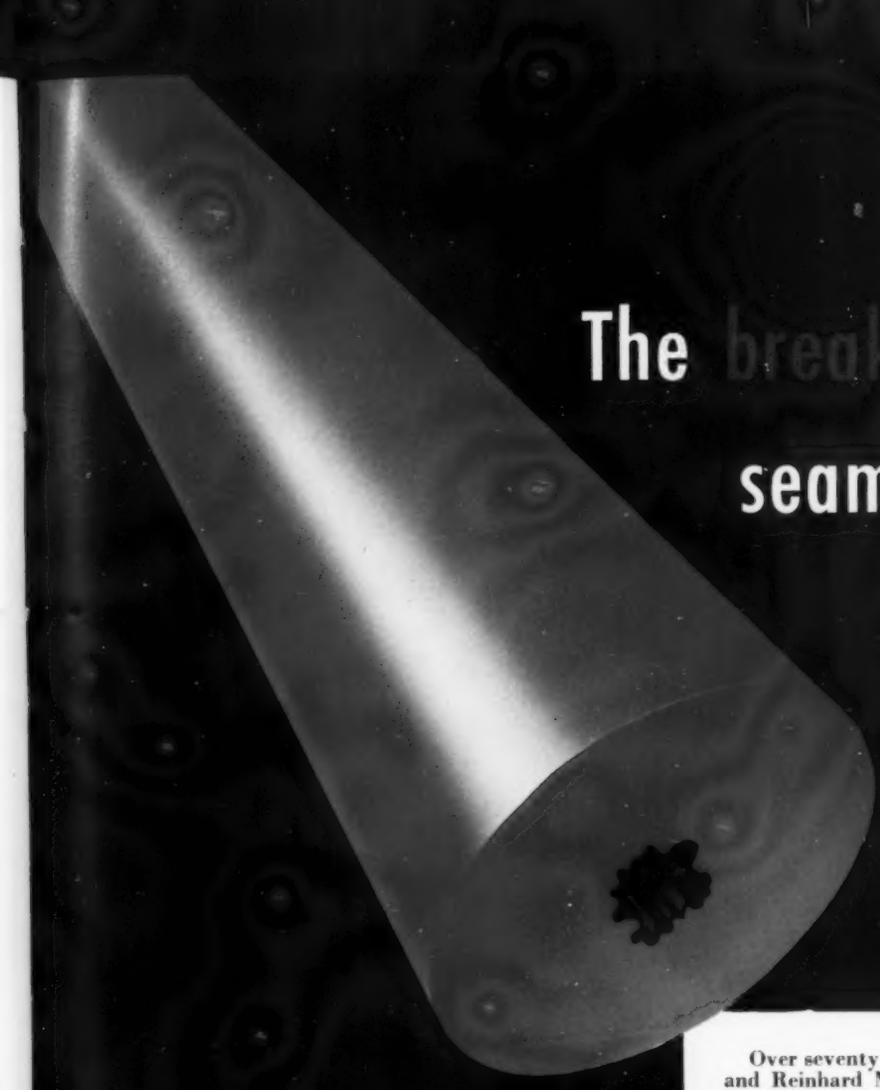
FOR MORE FACTS about these three rugged Bristol Furnace and Oven Controls write for free Bulletin P1260 today. It's a 48-page booklet of useful data, specifications, control diagrams and prices for every type of automatic heating control. The Bristol Company, 123 Bristol Road, Waterbury, Conn. 5.5

TRADE MARK BRISTOL'S REG. U.S. PAT. OFFICE

BRISTOL

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



The break that gave seamless tubing its start

Over seventy years ago the Mannesmann story began while Max and Reinhard Mannesmann, sons of a German file manufacturer, were investigating the development of centralized holes in steel bars that had been rounded and polished on a skewed-roll reeling machine. Their experiments proved that the faults were caused by the reeling process. Suddenly it occurred to the Mannesmann brothers that the same rolling technique could be carried to an extreme to produce a hollow tube.

There is probably no better way to highlight the importance of this discovery than to quote the American Iron and Steel Institute when it described the process of making seamless tubing as "THE GREAT PIPE TRICK," calling it "one of the neatest achievements of the Steel Industry," when "putting a hole down the middle of a tough steel round and leaving no visible trace of how it got there."

Today in nine out of ten seamless mills around the world Mannesmann piercing mills perform the great pipe trick up to 250 times per hour to meet the needs of the oil industry, to help make more efficient boilers and to satisfy the growing demand for seamless tubing all over the world.

The great pipe trick is only one of the many "Firsts" linked with the name Mannesmann. Now the American Company, Mannesmann-Meer, brings to U. S. metal producers a combination of know-how, nowhere else available, that is based upon

- **CREATIVE ENGINEERING**
- **DESIGN EXPERIENCE**
- **OPERATING BACKGROUND**
- **AMERICAN MANUFACTURING SKILL**

and is ready to get to work on your pipe and tube mill problems. Let us know what they are. *Mannesmann-Meer Eng. & Constr. Co., Inc., 900 Line St., Easton, Pa.*

MANNESMANN-MEER

World Specialists in High-Speed Tube Mill Machinery

DRAVO

DESIGNERS *and* BUILDERS

BRIDGES AND UNLOADERS • TOWER-TYPE UNLOADERS
FLOATING CRANES • DRAVO RAIL CLAMPS
MODERNIZED TROLLEYS FOR EXISTING BRIDGES
WHIRLER CRANES • BARGE SHIFTERS
HYDRAULIC BUFFERS

Completely unloading 30,000 gross tons of ore in 30 hours is the typical performance of this new Dravo-designed and built ore unloader at The Marine Bulk Handling Corporation's Mobile, Alabama, terminal.

Ships from Venezuela and other foreign ports bring iron ore here for the Fairfield, Alabama plant of U. S. Steel's Tennessee Coal and Iron Division. The unloader has removed ore at a rate of 1800 tons per hour, using a 275 cubic foot capacity bucket with a hoist speed of 300 feet per minute. The smooth, fast performance is produced economically with the use of an adjustable voltage control system.

To find out how such a modern Dravo bulk material handling system cuts costs and increases production, accept our invitation to visit actual installations. There is no obligation for this service or for a copy of Bulletin 225 describing Dravo equipment. Write us today.

DRAVO
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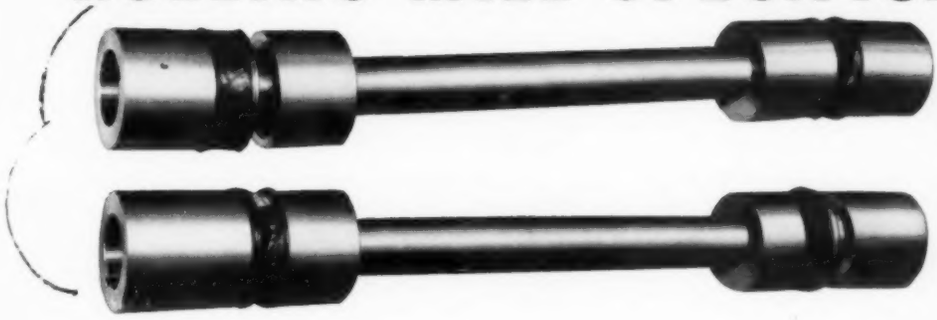
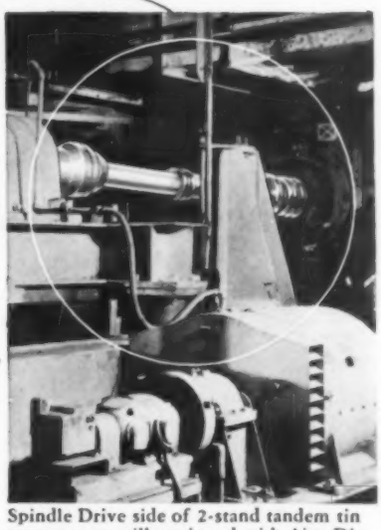
Air Conditioning • Boiler and Power Plants • Crane Cab Coolers • Docks • Industrial Foundations • Open Steel Flooring
Pump Houses and Intakes • Space Heaters • Water and Waste Treatment Plants • Towboats and Barges

AJAX DIHEDRAL SPINDLE SHAFT COUPLINGS

RE-WRITING ROLLING MILL SPECIFICATIONS!



* Patents Pending



Spindle Drive side of 2-stand tandem tin temper pass mill equipped with Ajax Dihedral Spindle Shaft Couplings designed to transmit 400 H. P. at 400 R. P. M.

AJAX DIHEDRAL COUPLINGS widen the narrow ranges of design previously restricted by small angular capacities inherent in conventional type couplings.

Out of a principle Ajax developed a vastly improved gear tooth design.* The Ajax Dihedral Flexible Coupling for direct-connected machines is an exclusive and basically new coupling, the very nature of which overcomes design, manufacturing, assembly and maintenance troubles which have been taken for granted as necessary evils over the years.

Ajax Dihedral Couplings handle offset and angular shaft misalignment up to a total of 12 degrees as well as end float. You can now design misalignment into as well as out of equipment where intermediaries between power source and driven equipment are subject to misalignment heretofore considered excessive.

Check Ajax Dihedral advantages listed at right,—then send for new Spindle Shaft Coupling Bulletin 58.

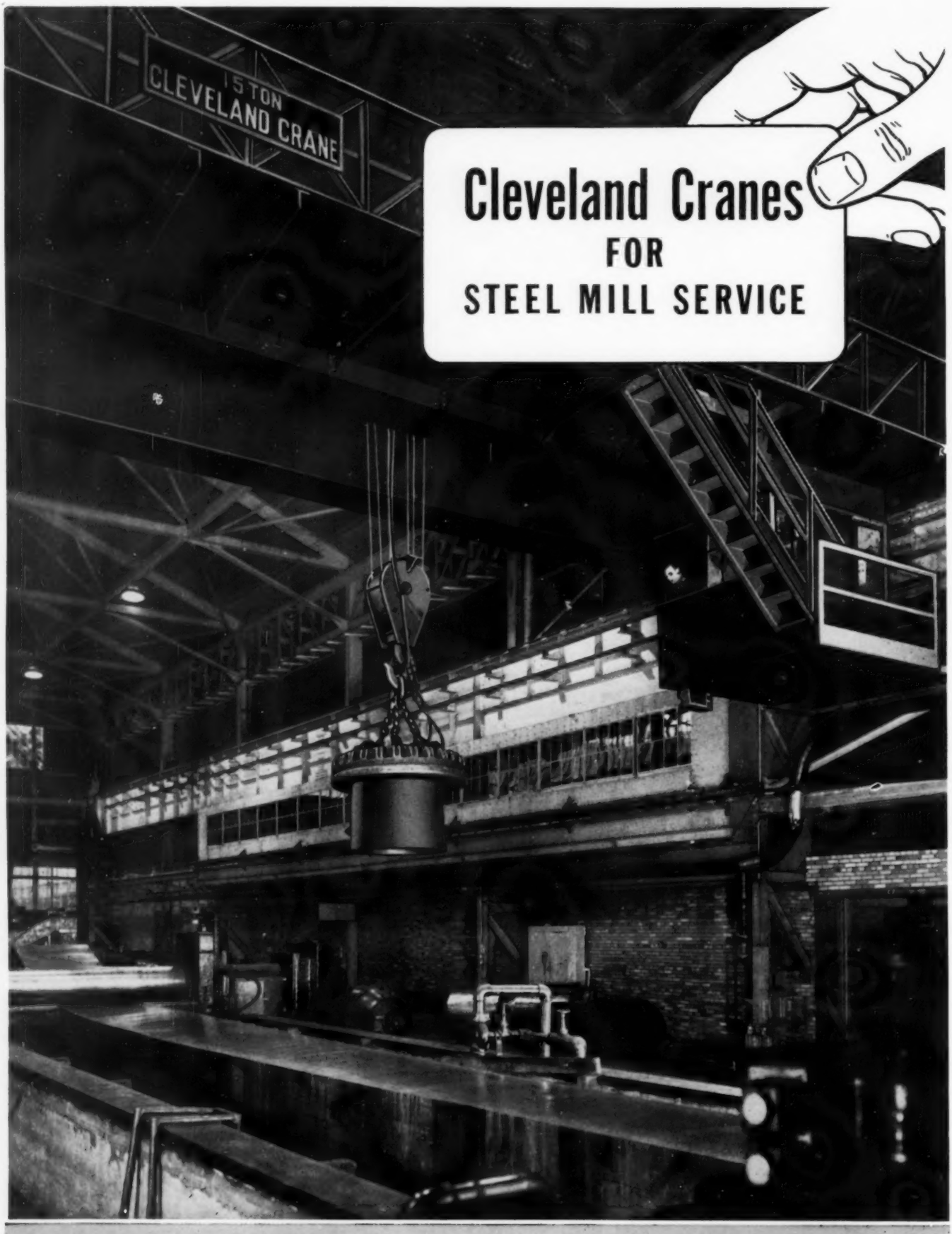
AJAX DIHEDRAL ENGINEERING AND PERFORMANCE FACTS

1. Handles shaft misalignment,—offset and angular up to a total of 12 degrees as well as end float.
2. Ajax design permits holding tooth clearance to lubrication film requirements.
3. More tooth area in contact under misalignment than with any other shape tooth.
4. Load is distributed at center of teeth at point of greatest strength.
5. All teeth hardened to 50-50 Rockwell C to combine hard wear surface with tough core.
6. Seals keep lubricant in and dirt out.
7. Constant peripheral speed.
8. No end-of-tooth contact even under maximum misalignment.
9. Free end float.
10. Standard sizes to fit ½" to 11" shafts.
11. Available in regular single and double engagement, mill motor, floating shaft and spindle shaft types.

AJAX FLEXIBLE COUPLING CO. INC.

REPRESENTATIVES IN PRINCIPAL CITIES

WESTFIELD, N. Y.



CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops *and* Shorts

BUSINESS and Defense Services Administration is rechecking present steel capacity against possible wartime needs, and may ask for another 10,000,000 tons a year. Steel producers will doubtless agree to build the additional capacity if rapid amortization is granted.

Thus far this year, six of the larger steel producers have filed more than 30 applications for certificates of necessity, involving some $452,000,000. United States Steel Corp. has asked for 15 items at Chicago, Duquesne, Fairless, etc., totaling $288,000,000. Bethlehem, with 11 items, wants to spend $105,000,000, principally at Sparrows Point. Inland, Jones & Laughlin, Youngstown Sheet and Tube, and Colorado Fuel and Iron also have filed applications.

Recently, certificates of necessity have not been forthcoming except for open hearth and electric furnace facilities, but a further expansion should open up the situation on blast furnaces, coke ovens, ore and stone facilities, ore carriers, etc.

▲

AN item in Changing Times observes "If the outdoor cooking season continues at its present pace, 69 per cent of the population will be in the hospital by August, having their carbon removed."

▲

IT is estimated that, by 1975, the United States will be importing almost 65,000,000 tons of iron ore from Canada and Venezuela.

▲

IF you've just returned from an automobile trip, you won't believe this, but there are approximately 10,000,000 motor trucks in use in the United States. And if you think it's bad now, meditate a while on the prediction that the number will more than double in the next 20 years.

▲

THE U. S. Senate seems to worry because the stock market has gone up almost 50 per cent in the past two years, but the same increase in their own salaries doesn't seem to bother them.

▲

NOW that the shortest general steel strike (which we didn't expect) is over, and steel wages have gone up 15 cents an hour (which this page predicted last month), and steel prices have been increased (which was also predicted here last month), we're well on our way on another whirl of inflation.

Actually, comments of steelworkers seemed to indicate they personally preferred going on without a raise to striking. A steelworker's wife, who said, "I suppose the price of bread will go up now," seems to have a better grasp of long-range economics than union leadership has.

Union leaders have become embroiled in competition to out-do each other that is becoming increasingly dangerous. Continued, it can lead only to disastrous inflation or, if industry finally decides it must be stopped, to disastrous strikes — and who's to predict which will be worse.

▲

AN observant correspondent says that, if it's true that women dress to express themselves, some of them have very little to say nowadays.

▲

THE French National Railroads set new speed records with trains consisting of an electric locomotive pulling three cars. In test runs, one unit reached 198 miles per hour and another set a mark of 207 miles per hour.

▲

SOME of the things you find growing in gardens and lawns make you doubt that you can't get something for nothing.

▲

THAT we live out of tin cans is well documented by our use of 36,000,000,000 cans a year, but don't forget the billion collapsible tubes we use each year, plus all those plastic "poof" bottles that occupy so much time on TV.

▲

THE Hoover Commission has done some good work in its efforts to reorganize the federal government setup and take it out of competition with private enterprise — so much so that many of its recommendations have been bitterly attacked by various pressure groups. To insure further progress, we should actively support this program and insist upon positive action by Congress.

▲

AN analytical friend of ours says that a smart girl neither lets a fool kiss her nor a kiss fool her.

▲

THE iron and steel industry's payroll for May was higher than in any previous month, being estimated at 654,000 employees. The payroll was estimated at $294,073,000.

The average hourly payroll cost of wage earners was $2.404 per hour in May, but pensions, social security and insurance raise this figure to $2.583. Wage earners worked an average of 39.7 hours per week.

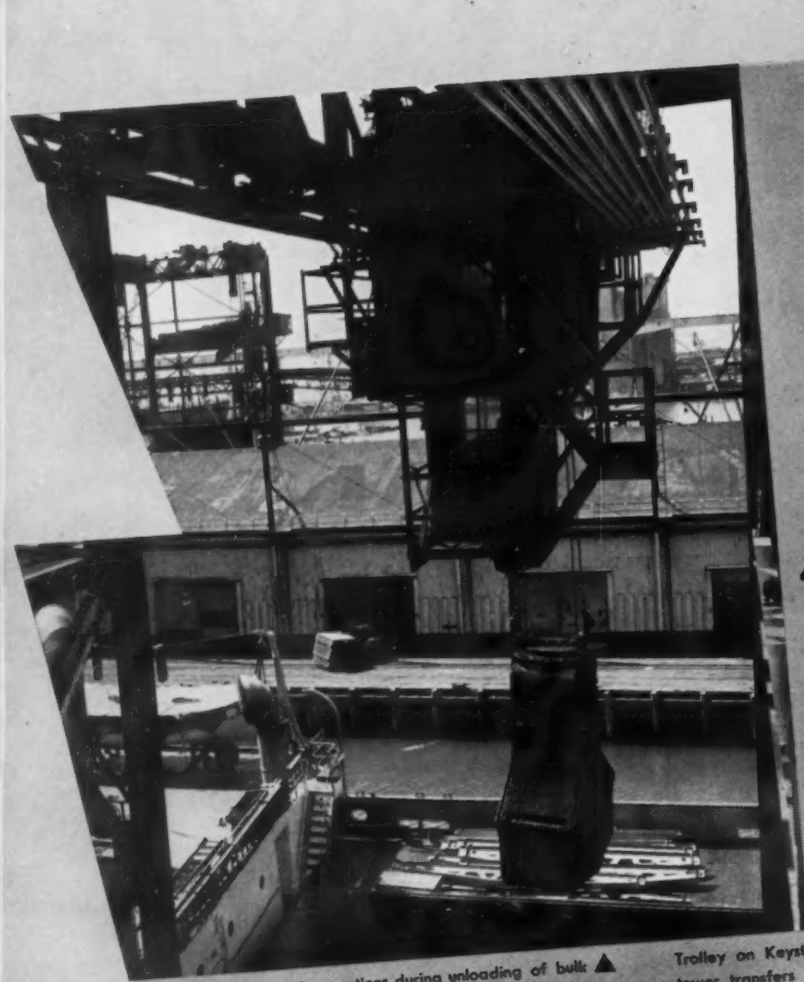
▲

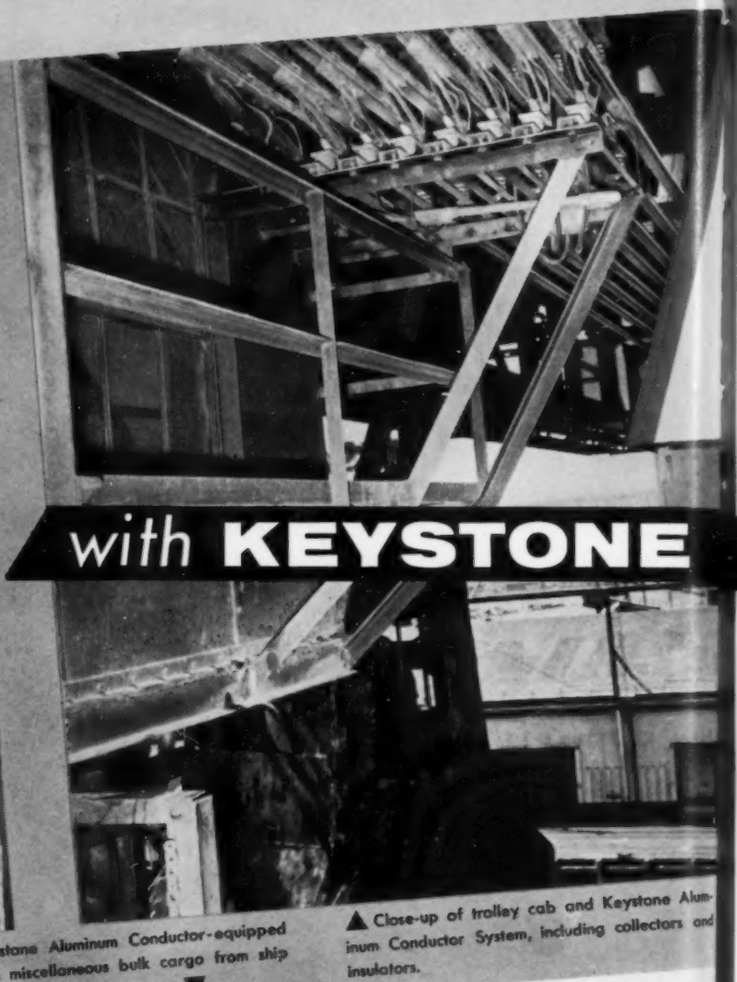
THE Wall Street Journal says the only time some people are not tight is when they are.

▲

TOTAL employment in the United States in June exceeded 64,000,000 for the first time in our history.

Unloads with GREATER SPEED... LESS



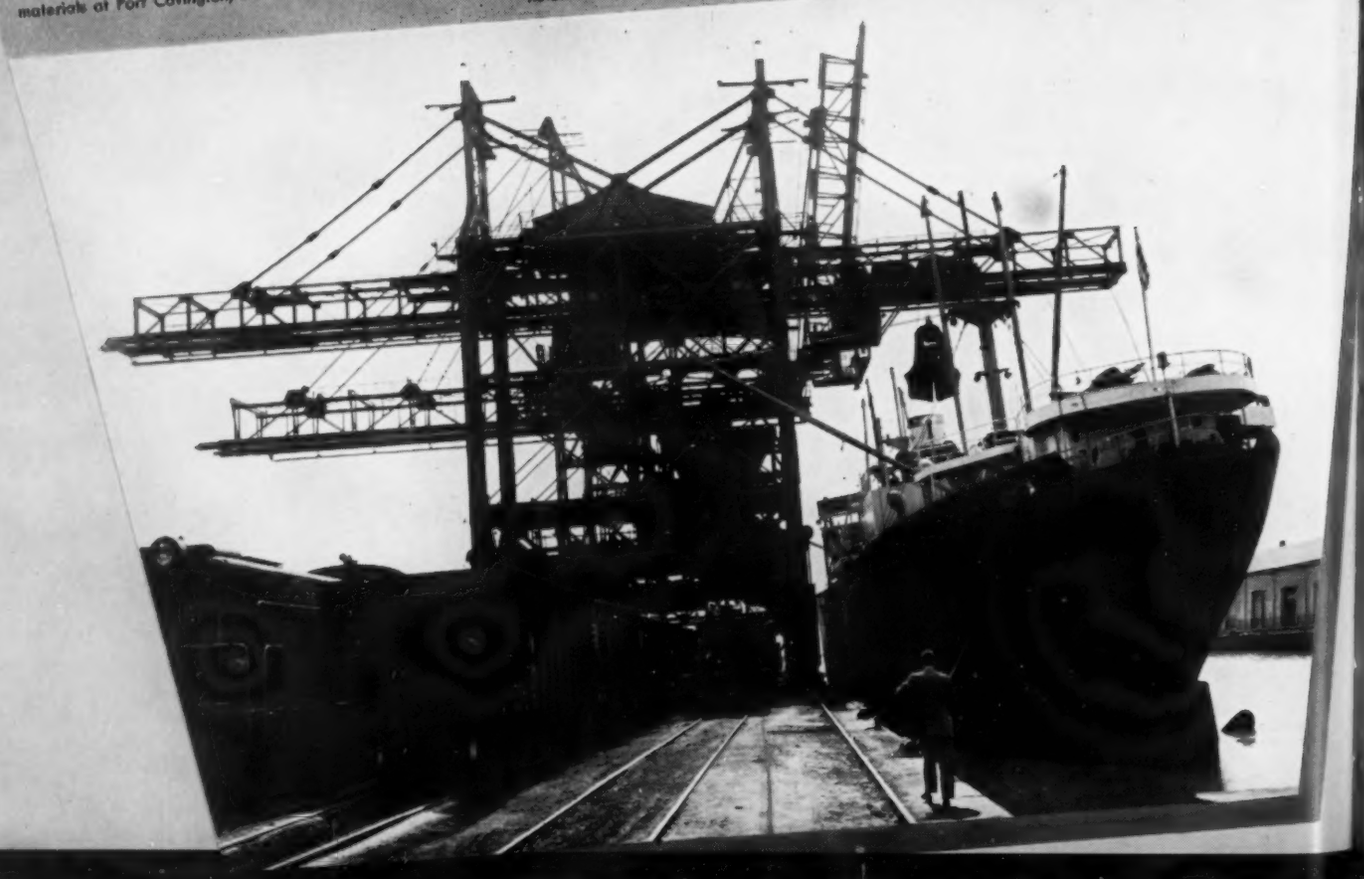


with KEYSTONE

▲ Bird's-eye view of operations during unloading of bulk materials at Port Covington, Baltimore Harbor.

Trolley on Keystone Aluminum Conductor-equipped tower transfers miscellaneous bulk cargo from ship holds to waiting freight cars. ▼

▲ Close-up of trolley cab and Keystone Aluminum Conductor System, including collectors and insulators.



ELECTRIC SERVICE MFG. CO

MAINTENANCE...
INCREASED TONNAGE...
FEWER INTERRUPTIONS...

Integrated Aluminum Conductors

at Western Maryland Railway

FASTER, more economical handling of ore and other materials has resulted from replacement, with a KEYSTONE Integrated Aluminum System, of all old trolley conductors on the double-apron unloading tower at the Western Maryland Railway docks at Port Covington, Baltimore Harbor.

SPEEDY CARGO TRANSFER from ship-to-shore is important in getting highly competitive ore-unloading business along the Eastern Seaboard. Ship operators want fast unloading, to give them quick ship turn-around . . . less time for ships in port . . . more time for profitable cargo-carrying.

TO SPEED turn-around, Western Maryland Railway modernized its facilities by replacing old copper and steel conductors with Keystone aluminum a year ago. Benefits resulting from it are:

Higher Speeds **. . . no longer a need to "trolley" at low speed to avoid breakdowns; greater efficiency in power conductor gives unloader more "pickup" capacity.**

Fewer Work Stoppages **. . . new conductors eliminate frequent breakdowns and derailments.**

Greater Tonnage **. . . from overall greater efficiency; more ships now unloaded without proportionate increase in cost.**

Cheaper Maintenance **. . . due to fewer conductor breakdowns while unloading; upkeep reduced to regularly scheduled, less costly preventive maintenance. Equipment burnouts sharply reduced.**

Why THE KEYSTONE INTEGRATED ALUMINUM CONDUCTOR SYSTEM GIVES LONGER, BETTER SERVICE

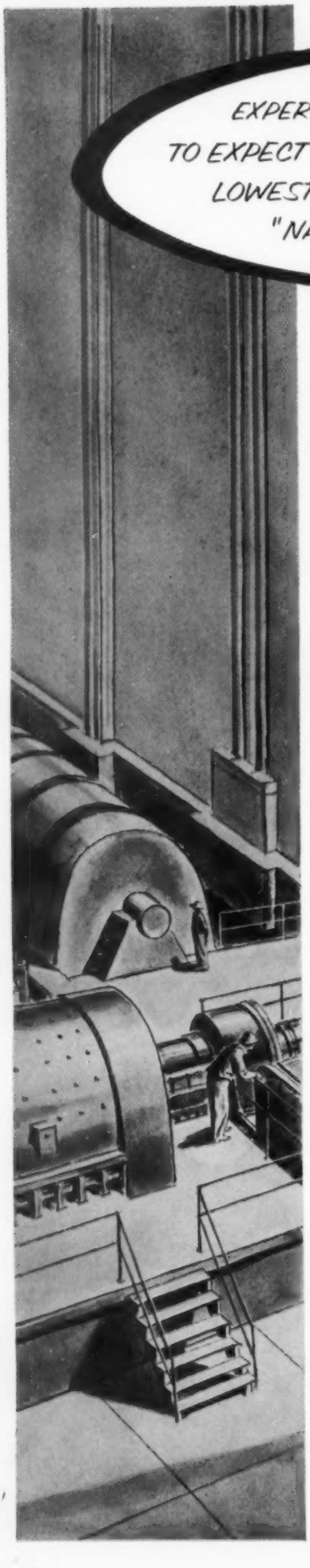
Durable — Aluminum lasts longer in destructive atmospheres. Contact surfaces stay smoother and cleaner than steel . . . prolong shoe life. Multiple contact collectors prevent arcing and heating. Less vibrating weight saves insulators.

Lightweight — Permits prefabrication of units, to reduce cost of installation, insulators and supporting structures. Compact design saves space, permits better protection with standard enclosures.

Voltage and Capacity—Non-magnetic aluminum increases current capacity through lower reactance, and permits closer conductor spacings. Ample capacity for other equipment without need for boosters or multi-point feeds. Pre-engineered systems now operating to 6000 amp capacity.

Write today for Booklet 439 on Keystone Integrated Aluminum Conductor Systems.

Philadelphia 32, Pa.



EXPERIENCE HAS TAUGHT US TO EXPECT TOP PERFORMANCE AND LOWEST OVERALL COST FROM "NATIONAL" BRUSHES.

LOOKING FOR WAYS TO SAVE MONEY? TRY THIS ONE:

If you're not already using "National" brushes on rotating d-c equipment throughout your mine or mill, prove to yourself that this traditionally dependable brush line can effect the following savings for your department:

- **Longer Brush Life** — "National" brushes give you the most hours of trouble-free service consistent with other important performance factors. National Carbon research is continually at work on this and other features of "National" brushes.

- **Lower Maintenance** — Often much more important than frequency of brush replacement is commutator condition — a direct result of brush performance. The excellent commutating ability and low friction of "National" brushes contribute to low-cost commutator care.

- **Uniformity** — Brush quality is a link in the chain of dependability upon which uninterrupted service of your equipment depends. National Carbon's inspection procedure is designed to assure you of the same uniformly high quality year after year, from box to box and shipment to shipment.

Brush selection is neither a small nor a simple thing. Install "National" brushes in accordance with recommendations of a National Carbon representative. Then expect and *get* the lowest overall brush cost you ever had!

Are you getting the "Brush Digest"? Many thousands of this free, serialized, motor maintenance course are being distributed to their men by electrical and maintenance supervisors. Write for your copies today!

The term "National", the Three Pyramids Device and the Silver Colored Cable Strand are registered trade-marks of Union Carbide and Carbon Corporation

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Iron and Steel ENGINEER

JULY, 1955 VOLUME XXXII NUMBER VII

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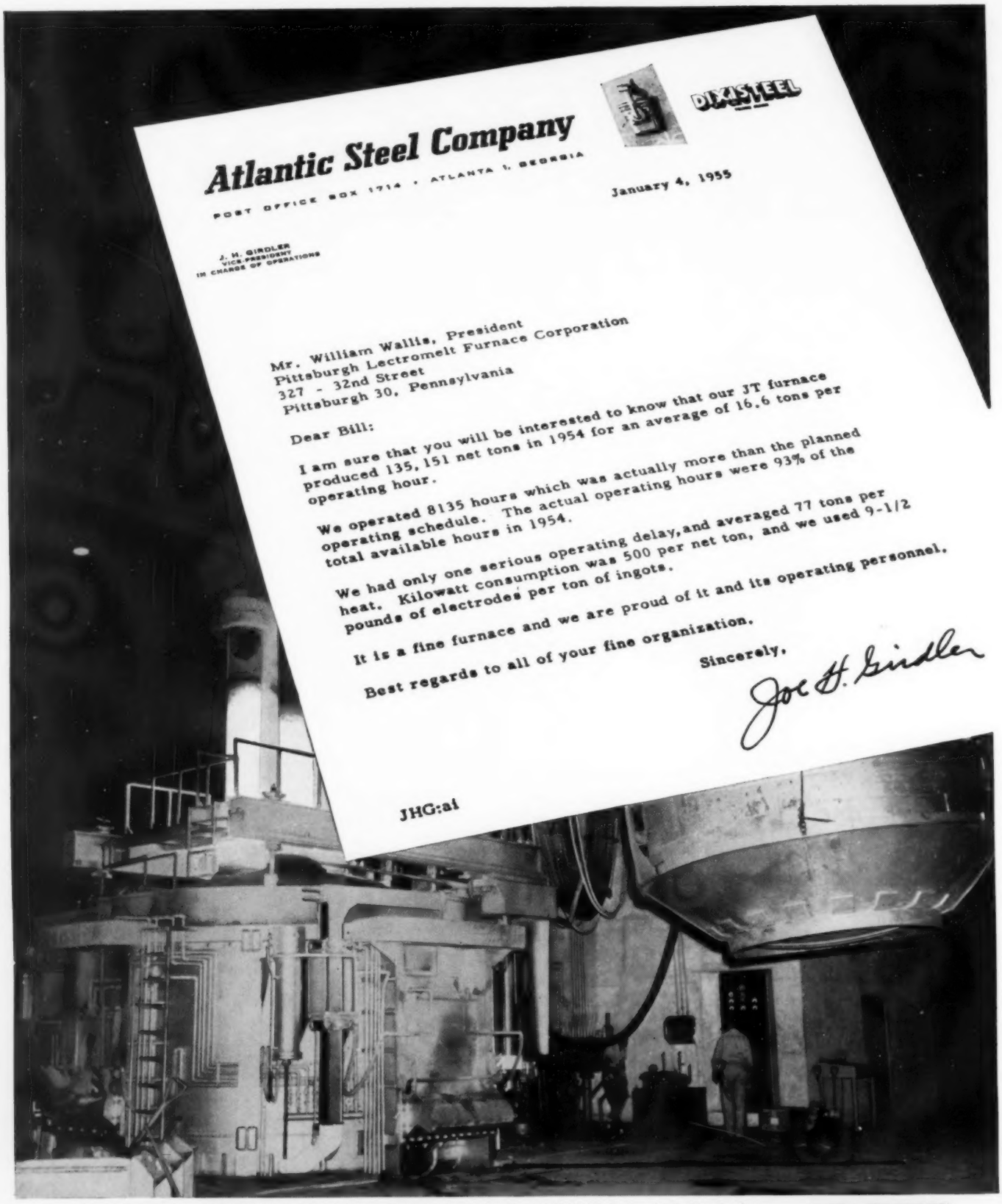
Atlantic Steel Company
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January 4, 1955
J. H. GIRDLER
VICE-PRESIDENT
IN CHARGE OF OPERATIONS
Mr. William Wallis, President
Pittsburgh Lectromelt Furnace Corporation
327 - 32nd Street
Pittsburgh 30, Pennsylvania
Dear Bill:
I am sure that you will be interested to know that our JT furnace produced 135,151 net tons in 1954 for an average of 16.6 tons per operating hour.
We operated 8135 hours which was actually more than the planned operating schedule. The actual operating hours were 93% of the total available hours in 1954.
We had only one serious operating delay, and averaged 77 tons per heat. Kilowatt consumption was 500 per net ton, and we used 9-1/2 pounds of electrodes per ton of ingots.
It is a fine furnace and we are proud of it and its operating personnel.
Best regards to all of your fine organization.
Sincerely,
Joe H. Girdler
JHG:al

Manufactured in...GERMANY: Friedrich Kocks GMBH, Dusseldorf...ENGLAND: Birlec, Ltd., Birmingham ... FRANCE: Stein et Roubaix, Paris... BELGIUM: S. A. Belge Stein et Roubaix, Bressoux-Liege ... SPAIN: General Electrica Espanola, Bilbao ... ITALY: Forni Stein, Genoa. JAPAN: Daido Steel Co., Ltd., Nagoya

*REG. T. M. U. S. PAT. OFF

MOORE RAPID

WHEN YOU MELT... *Lectromelt*

Detroit Steel Corporation's MULTIPLE-FUELED Soaking Pits

By F. C. McGOUGH
Superintendent Fuel and Power Dept.
Detroit Steel Corp.
Portsmouth, Ohio

. . . . installation has shown that it is practical to fire circular type pits with low calorific mixed gas and preheated combustion air with burners which can also handle richer gases . . . . no adverse effects have been noticed on mill operations and definite savings have been accomplished from the use of blast furnace gas . . . .

▲ IN 1950, the plant acquired by Detroit Steel Corp. at Portsmouth was rated at 660,000 annual ingot tons, and capable of producing only semi-finished, rod and wire products. With the exception of the rod and wire operations, it was recognized that the facilities as they existed, were out-dated and unbalanced. If the economic and quality requirements of the post-war market were to be successfully met, it was obvious that extensive plant expansion and rehabilitation was a necessity. Therefore, a plan which had as its objective a balanced and modern steel plant, with its ingot capacity doubled, was developed and implemented.

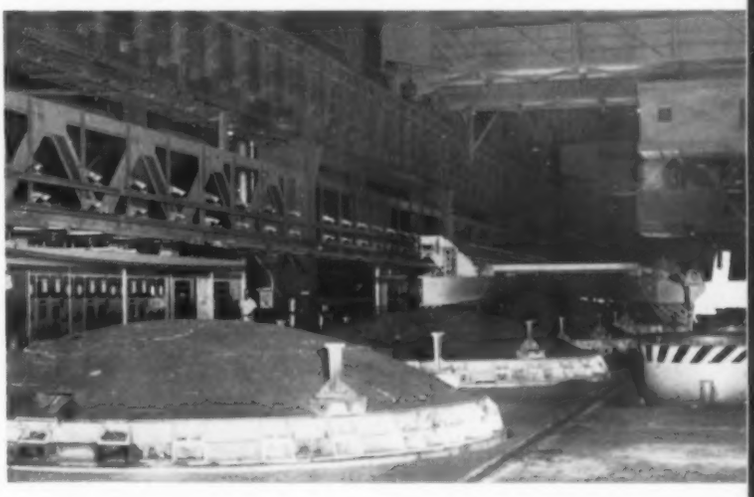
Basically, the expansion consisted of additional blast furnace and open hearth capacity, the complete replacement of obsolete soaking pit and blooming mill facilities, and a new 54-in. hot and cold strip mill. During the time this construction was underway, existing plant operations, services and auxiliaries were completely revamped and supplemented. It is worthy of note, that while both these projects were being concurrently accomplished, basic operations continued without serious interruptions, and with a minimum loss of tonnage.

The 54-in. hot strip mill was placed into operation in the summer of 1952, and the cold mill began production the first of 1953. No. 2 blast furnace, one of the world's largest, was blown in and brought into iron production in August of the same year. In February 1954, the first heat was tapped from No. 2 open hearth shop, and on the same day was heated in the new pits and rolled on the 44-in. high-lift blooming mill. This, in a general way, gives the background of the plant of which the subject of this paper, the new soaking pits, are a part.

GENERAL DESCRIPTION

The pits are located along the north side of a building 577 ft long by 114 ft wide (Figure 1). Ingots are stripped

Figure 1 — Ingots are handled by two 25-ton ingot cranes.



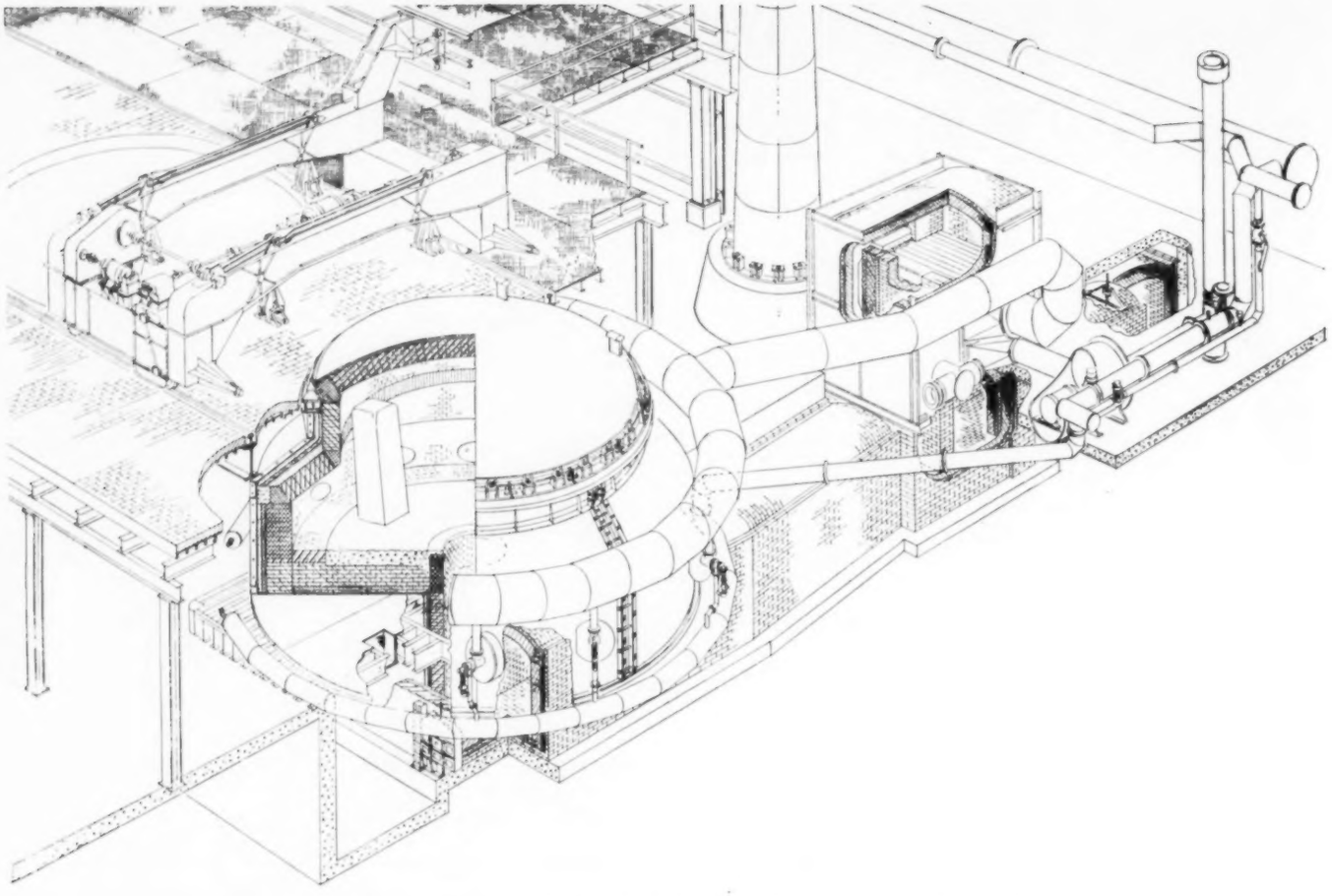


Figure 2 — Perspective drawing shows soaking pits at Detroit Steel's Portsmouth works.

in the east end of the building by a 400-ton stripper crane, and handled in and out of the pits by two 25-ton ingot cranes. Along the immediate south side of the pits is the ingot buggy run which delivers the heated ingots to the 44-in. blooming mill, located in an adjacent and adjoining building to the west. The south side of the pit building contains stripping and service tracks, and an ingot storage area.

The ingot heating facilities proper consists of ten direct-fired pits of the circular type. Provision has been made for the future installation of two additional units in the east end of the pit building.

Each pit is 18 ft inside at the top, 22 ft 9 in. inside at the burner level, and 9 ft deep from the parting line of the cover to the top of the bottom (Figure 2). Fuel is released through ten burners tangentially located around the periphery of the combustion chamber. The products of combustion exhaust through a four-ft diam opening in the center of the bottom. Flue gases are carried through individual pit flues and needle type metallic recuperators, and are collected in main flues leading to the stacks. Two 25-ton cover cranes handle the dome type covers for the charging and drawing of ingots. The totally enclosed control panels are located on the north side of the pits along the full length operating platform.

BASIC CONSIDERATIONS

The selection of fuels for any given steel plant operation is determined by certain definite economic fundamentals. In our case, under normal operating conditions, the old regenerative pits had been fired with straight coke oven gas. At the same time, the limited availability of this fuel required the purchase of natural gas for heavy heating operations in the 54-in. hot mill and rod mill.

Since no additional coke plant facilities had been included in the expansion program, the amount of surplus coke oven gas produced remained a constant. However, the additional blast furnace capacity resulted in a source of fuel gas that was far in excess of the amount which could be consumed by existing blast furnace plant steam generation and which was required for heating furnace stoves. It was, therefore, fundamental that maximum blast furnace gas should be utilized for ingot heating. It also followed, that the use of coke oven gas should be held to a minimum, so that the amount of purchased fuel could be reduced. These facts definitely established that the basic fuel for the new soaking pits should be a low calorific mixed gas. The case was further strengthened by the superior qualities of this type fuel for ingot heating. It also made mandatory the recuperation of combustion air. Some circular pit installations in Europe had satisfactorily utilized blast furnace gas through the recuperation of both the gas and air. However, all existing operations in this country were fired with high thermal fuels and no means of recuperation. Practically speaking, no similar application or experience was available for first hand investigation and evaluation.

It was necessary, therefore, to principally depend upon good engineering and operating practice to obtain

solutions for the problems presented. Accepting the premise that the circular type soaking pit had been established as a basically sound and practical furnace design, the factors to be considered were:

1. A system to supply clean blast furnace gas to the pits.
2. The method of firing the pits.
3. Recuperation of combustion air.
4. The selection and application of control equipment.

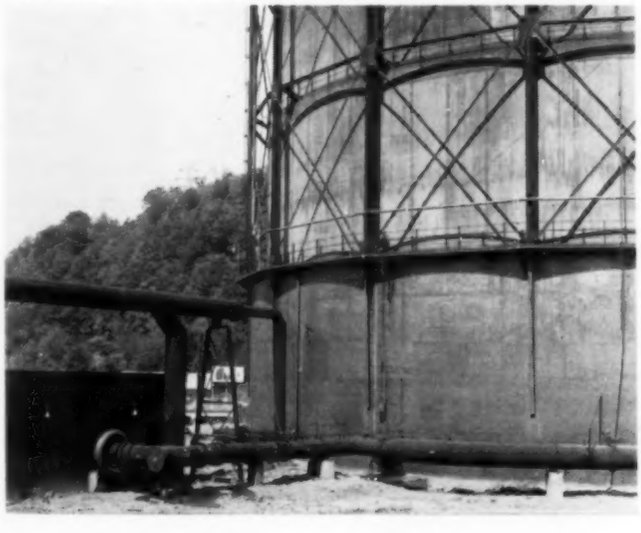
THE BLAST FURNACE GAS SYSTEM

New electrostatic precipitators installed common to the gas systems of the two blast furnaces had available sufficient clean gas capacity to satisfy the maximum demands for ingot heating. However, any system to be considered had to be capable of insuring a constant supply of gas to the pits during limited periods of interrupted gas production. If such conditions became prolonged, it must also have sufficient inherent capacity to allow time for the pits to be transferred to an alternate fuel without adversely affecting the production of the blooming mill. As definite possibilities of single blast furnace operation existed, it was an absolute necessity that this situation be considered. It was, therefore, evident that a blast furnace gas holder must be included in the installation.

Approximately half way between the blast furnaces and the pits, located about 2800 ft apart, a 2,000,000-cu ft wet seal holder was installed (Figure 3). As a source of supply, a 40-in. line was taken off a 78-in. clean gas crossover main running between the furnaces and the blast furnace boiler house. This main was terminated in a T-connection adjacent to the holder, one outlet feeding into the holder and the other into a 21,000-cfm booster. The booster outlet was in turn connected to a 36-in. main, which carried the gas to the soaking pit area.

Through the application of hydraulic regulators, all phases of the operation of the holder and booster were made fully automatic (Figure 4). A specially designed regulator controls the height of the holder and also automatically feeds back gas from the holder to maintain a preset minimum safe static pressure in the furnace gas system. This has eliminated the necessity for the conditions resulting from the steam purging of the clean gas system during "wind off" periods of single blast furnace operation. The discharge pressure of the booster is controlled by a hydraulically operated inlet butterfly valve. To eliminate the possibility of pulling the holder "flat," the discharge pressure is determined and automatically set by a control actuated by the holder height. Another regulator, operating a butterfly valve in a by-pass line between the booster discharge and the holder, maintains a minimum volume through the machine to avoid pumping conditions.

Figure 3 — A 2,000,000-cu ft gas holder was installed.



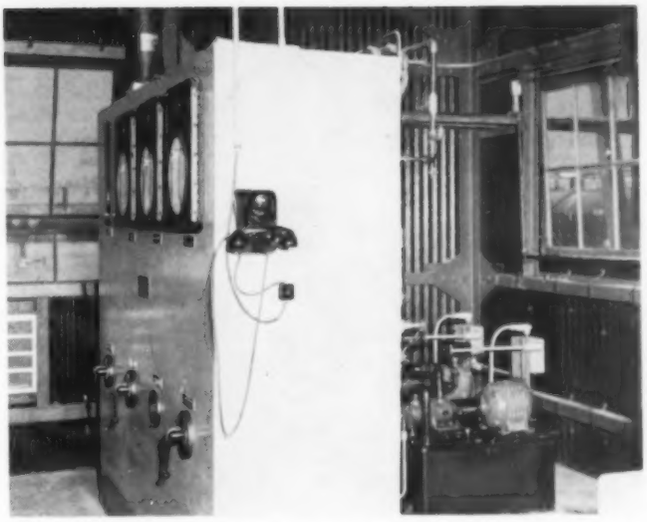


Figure 4 — Operation of gas holder and boosters is fully automatic.

These controls, in conjunction with others installed on the 78-in. main to the boilers and on a wet washed gas bleeder, have allowed the complete control of gas conditions throughout the system from the blast furnaces to the pits with a minimum of personnel supervision.

METHOD OF FIRING

With an adequate supply of blast furnace gas now available in the soaking pit area and at the required pressure, the next factor to be considered was a method of utilizing this gas for firing the pits. Alternate fuels must also be considered for times when blast furnace gas was not available. The final solution evolved as a choice between one of the following approaches, either of which apparently could meet the basic requirements for a low Btu mixed gas:

1. Separately piping blast furnace and coke oven gas to each pit through individual metering runs and control valves, and mixing the two just prior to entering the circular burner manifold. Each pit could be equipped with an arrangement of controls so that the mixture could be infinitely varied between the extreme limits of straight blast furnace and straight coke oven gas. This, in effect, would give the heater control over a mixing station for each pit, and allow him to regulate the thermal quality of the mixed gas as required for certain specific operating conditions. For example, a heat charged cold off the bank might initially be fired with practically straight coke oven gas, while a hot heat, with short track time, would be fired with a slightly enriched blast furnace gas.
2. The other approach was to pipe the blast furnace and coke oven gas to a mixing station, and deliver the mixed gas at a standard heating value to the

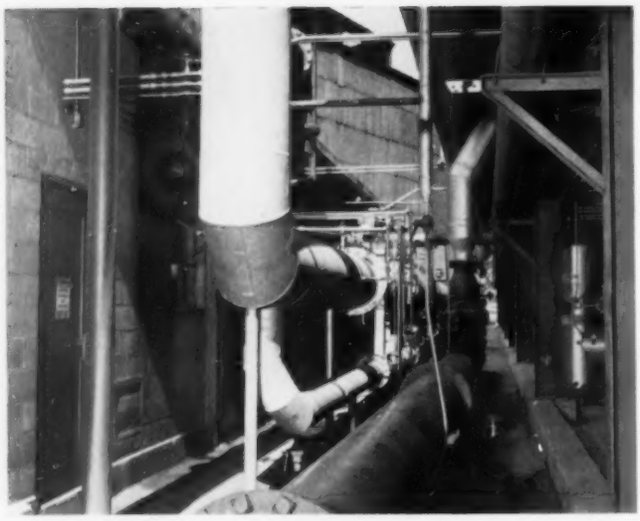


Figure 5 — Blast furnace and coke oven gas are mixed volumetrically.

individual pits. This method would tend to minimize the heater's judgment in the determination of the gas quality required. It would likewise necessitate the establishment of an accepted heating value for the mixed gas which could satisfy average operating conditions, and also meet the requirement that the maximum utilization be made of blast furnace gas.

In the case of the first approach, control systems would have to be engineered that could simultaneously vary the volumetric ratios to produce the desired heating value of the mixed gas, and also control the total Btu input to maintain the required temperature level. This would necessitate special equipment for the individual pits, in addition to the standard controls for maintaining fuel-air ratios and furnace pressure. The complexities of such a system, plus the inevitable differences of opinions that would exist among the heaters in varying the Btu value of the mixed gas, made the practicability of such a method questionable.

In view of these facts, it was decided to adopt the second method and a station to volumetrically mix blast furnace and coke oven gas was installed outside the north side of the new pit building (Figure 5). Controlled by hydraulic regulators, it was designed to produce mixed gas at any desired heating value between 140 and 200 Btu per cu ft. Sufficient capacity was incorporated in the equipment to allow for anticipated loads if additional pit installations were contemplated. The station is capable of holding ratio at minimum loads, and no difficulty has been experienced in maintaining the Btu required at a fifty to one turn down. The heating values of the component gases and the mixed gas are recorded, as are all pertinent flows and pressures (Figure 6).

As previously stated, the possibilities of prolonged interruptions of blast furnace gas production during single furnace operation had to be recognized. This definitely indicated that an alternate fuel must be immediately available for ingot heating, so that such situations would not adversely affect the blooming mill operation. If its supply could be insured, it was logical that straight coke oven gas should be the alternate soaking pit fuel. However, this could only be accomplished by having available a means of producing a coke gas equivalent during deficiency periods. Therefore, equipment to volumetrically mix natural gas and air was installed in the same building and area as the mixed gas station, and the equivalent gas was piped into the coke oven gas distribution system.

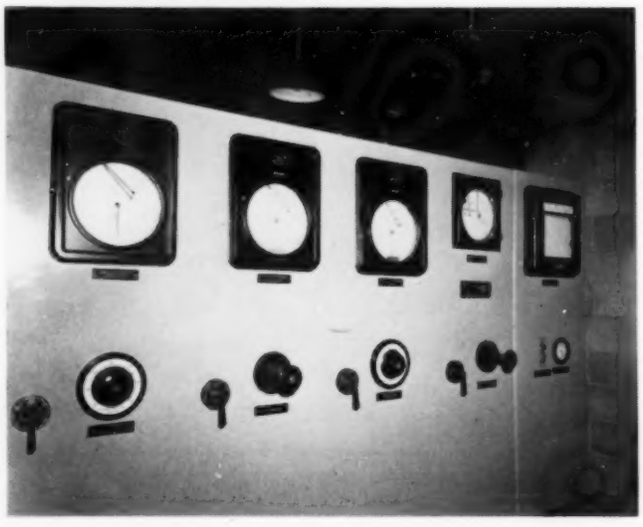
BURNER EQUIPMENT

Having selected and provided for the primary and alternate fuels for the ingot heating operations, the next step to be considered was the burner equipment proper. The foregoing conclusions had automatically specified the conditions that the burners to be applied must satisfy. Basically they were required to utilize hot air to equally and effectively fire either low calorific mixed gas, coke oven gas or its equivalent. They must also be capable of becoming an integral part of a firing system that could quickly and easily be transferred from the one fuel to the other. In addition, another factor was interposed. Due to the conditions that existed as regarded the supply of natural gas, it was considered advisable to incorporate the firing of a third fuel, No. 6 oil.

It was obvious that these fuels had many times previously been fired independently or in combination by a number of burner types and designs. However, it was also evident that no similar direct fired ingot heating operation existed that required the quick transfer between a low and high calorific gas, plus the capabilities of firing a liquid fuel on an emergency basis.

The burner manufacturer, therefore, undertook an extremely difficult assignment in developing a burner that could satisfy all the specific requirements and still be within the limits of good design fundamentals. It was necessary to avoid the making up of any pipe or the changing or retraction of gas tubes so that the transfer of fuel gases could be made easily and without delay. The long port block common to the tangentially fired circular pit made it imperative that excessive port block temperatures be avoided so that satisfactory refractory life might be realized. The metallic parts of the burner, subjected to both the temperature of the hot air and the port block, had to be constructed in such a manner they would not become a maintenance problem. Finally, the burner design had to be such that,

Figure 6 — Complete records are kept on all pertinent gas flows and pressures.



in each case, the effective mixing of the fuel and the combustion air could result in the proper flame characteristics, furnace atmosphere and efficient fuel practice.

After considerable investigation and development, a burner design was finally arrived at an agreed upon. It consisted primarily of the incorporation of a two-in. coke oven gas tube running through the four-in. mixed gas tube of a burner which had previously been specifically designed for the firing of low Btu mixed gas with hot air. A gas nozzle on the end of the mixed gas tube projected into the port block through a refractory baffle. The combustion air was emitted into the block through a number of openings in the baffle and around the nozzle. The mixed gas was angularly directed into the streams of air through small openings in the gas nozzle. The coke oven gas was fed through the unrestricted tube into the block parallel to the flow of the air. The two gases were supplied from a common burner header, in each case individually piped and valved into their respective gas tubes.

The firing of No. 6 oil on this type pit had been an accepted practice for a number of years, and was not considered as any serious problem. Standard steam atomization type burner bodies were adapted, with provision made for the insertion of the emulsion tube through the coke oven gas tube.

RECUPERATION OF COMBUSTION AIR

As previously pointed out, the selection of a low Btu gas as the basic soaking pit fuel predicated recuperation for the preheating of the combustion air. Although never before specifically utilized with this type of soaking pit, it was the opinion that recuperation was merely one of selection and application.

Therefore, a metallic needle type double-pass recuperator was installed on each pit. The first pass consisted of 36 elements of 30 per cent chrome cast alloy and the second pass of 27 elements of cast iron.

Combustion air is forced through the recuperator by a 7400-cfm, 12-oz blower and delivered to the furnace through an insulated air header. Recuperator elements were protected from excessive temperatures by controlling the inlet flue gas temperature by means of atmospheric air dilution arrangement. Inlet temperatures are limited to 1750 F with a resultant combustion air temperature of 900 to 1100 F.

INSTRUMENTS AND CONTROLS

As in the case of the recuperator, the instruments and controls to be applied to the ingot heating operation did not present any major problem. Most steel mill operators and engineers have their own opinions and preferences regarding this matter, and these, naturally, were reflected in our particular selection of equipment. With the exception of a few special applications, all the instrument and control equipment installed was standard.

The control panels were located in three totally enclosed and pressurized houses, each approximately 36 ft long, conveniently placed along the soaking pit operating platform. The first two houses each contain the controls for four pits, while the third building houses the controls for the remaining two pits with provision for the panels for two additional pits. The fronts of the houses were kept as open as possible so that the heater could easily observe the controls from the operating floor through large heat-proof glass windows.

On a panel for each pit (Figure 7) is installed the following:

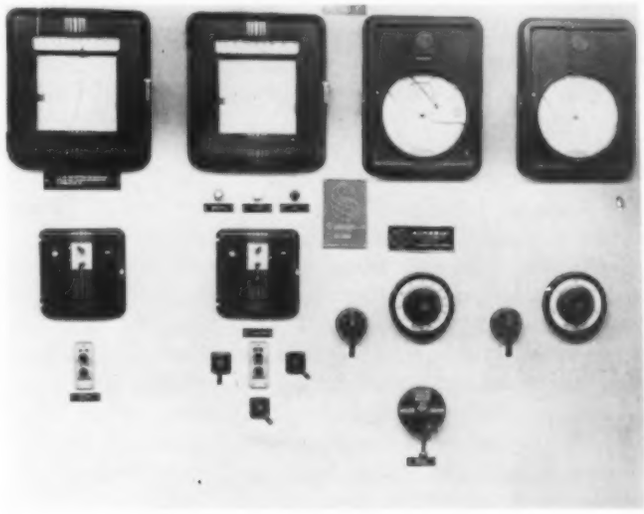
1. Systems for recording and controlling the temperatures of the furnace and the recuperator.
2. Regulators for controlling the furnace pressure and the fuel-air ratio.
3. Meters for recording furnace pressure, Btu input rate and combustion air flow.
4. Switching arrangements for fuel selection and transfer.
5. Lights to indicate the fuel being fired.
6. Push buttons for the combustion air blower and hydraulic pump.
7. A fuel shut-off button.

The pit temperature is proportionately controlled by a recorder controller which operates a motor driven valve in the supply line of the particular fuel being fired. The primary element is a radiation head which is sighted on the closed end of a ceramic tube located in the sidewall of the combustion chamber. Provision has been made for the installation of a second radiation head to sight through an open end tube and measure the temperature of the outlet flue. By means of a panel mounted switching arrangement, the temperature instrument can be operated as either a single point or a two point recorder controller. Another switch, similarly installed can select either of the radiation heads as the point of control, while the temperature of the second head is recorded on the same chart.

The recuperator inlet temperature is controlled by another recorder controller actuating a motor driven butterfly which admits atmospheric air into the flue gases entering the recuperator. A high limit contact in this instrument trips a second butterfly similarly located, in the event a preset safe inlet temperature is exceeded. On the same chart is also recorded the temperatures of the flue gases and the combustion air leaving the recuperator.

Combustion controls are of the conventional hydraulic type. A piston operated chrome iron damper located between the recuperator outlet and the col-

Figure 7 — Illustration shows typical panel used for each pit.



lector flue is actuated to maintain the desired furnace pressure. A differential regulator, receiving its impulse from an orifice located in the blower intake piping and from the metering system of the particular fuel being fired, hydraulically operates a butterfly valve to hold the proper air to fuel ratio. Since the air is metered at atmospheric temperatures, it is not necessary to compensate for temperature variations of the preheated air. To minimize fire hazards, a nonflammable fluid was used in the hydraulic systems.

Orifice runs to measure the flows of each of the gaseous fuels were installed in the supply piping between the mains of the distribution headers and the common burner manifolds of each pit. Due to the multiplicity of fuels, it was decided to record and integrate these flows on a Btu basis rather than volumetrically. This measurement is recorded on the same chart as the combustion air flow. The importance of proper furnace pressure in good heating practice was recognized by the installation of another meter to record this value.

INITIAL OPERATIONS

Even though every effort has been expended in the engineering of a project, it is only natural that the people involved in this work have certain apprehensions when the time comes for the job to be finally placed into operation after the seemingly long construction period. We were no exception.

The scheduled initial operations of the new pits were a part of a master plan, which included the production of steel in the new open hearth shop and blooming mill, and the termination of operations in the old blooming mill. At this time final construction had not been completed on the blast furnace gas handling system and it was the intention to initially fire the pits with straight coke oven gas. However, a temporary situation that existed made coke oven gas unavailable and it was necessary to light off the pits utilizing the equivalent mixture of natural gas and air.

During the drying out period, all phases of the

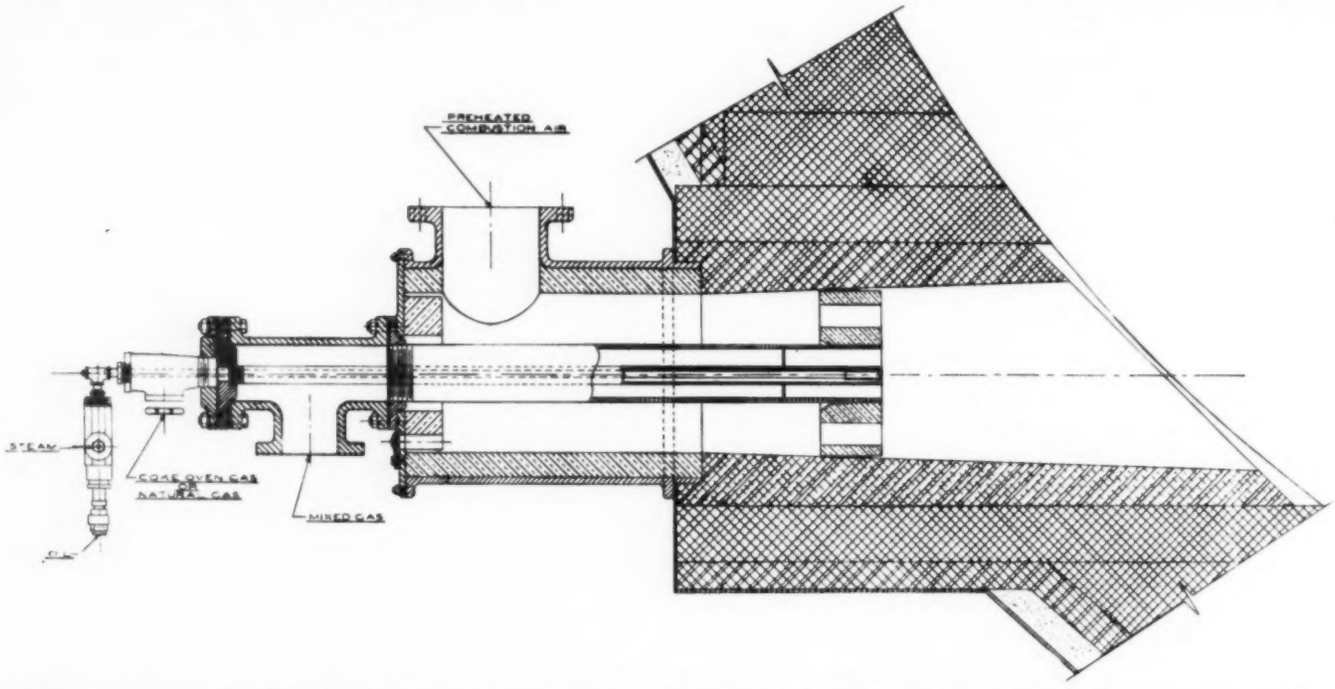


Figure 8 — Burners were designed to meet the difficult requirements of handling natural gas, coke oven gas, low Btu mixed gas or oil.

The necessity for being able to rapidly transfer from one fuel to another has already been pointed out. Panel mounted controls were installed so that this could be accomplished in a minimum amount of time. Included was equipment to remotely open and close main fuel supply valves, transfer the pit temperature controllers from one motor driven valve to another, and transfer the impulse piping of the combustion control regulators and recording meters. In this way, all operations of the selection and transfer are remotely completed with the exception of the actual opening and closing of the individual burner fuel valves.

In addition to the equipment described, the soaking pits are protected by the usual devices to prevent explosions due to power failures, loss of combustion air or insufficient gas pressure. Standard controls of the hydraulic type are also installed to maintain constant gas pressures in the distribution mains.

operation were closely checked and observed for equipment or design failures or deficiencies. No serious complications developed and the first ingot heating was accomplished in a very acceptable manner and was rolled as scheduled on the new mill.

However, during the subsequent week of operations, it became apparent that although good heating and operating conditions were being realized, the metallic parts of the burners that projected through the refractory baffle and into the burner block were being subjected to temperatures which caused them to deteriorate rapidly. Evidences of carbon deposits in the port blocks also indicated an improper mixing of the gas and air which was resulting in the breakdown of the hydrocarbons in the gas. To further complicate matters, the high percentage of oxygen in the mixed natural gas and air was causing an oxide deposit which resulted in the clogging of the coke gas burner tubes.

The seriousness of the situation was immediately recognized and a concentration of burner manufacturer, furnace builder and steel plant engineering talent converged on the problem. The first steps taken were emergency changes to the burners so that heating quality and blooming mill operations would not be affected. Then began the tedious investigations to determine the basic causes of the trouble and the corrections in burner design necessary to eliminate the undesirable conditions. Although it at first appeared that the eventual solution was to be an extensive and costly revamping of the burner equipment, the answer finally evolved as three simple changes to the existing burners. These consisted primarily of keeping all metal parts out of the port block, the elimination of the mixed gas nozzle and the replacement of the two-in. coke oven gas tube with a one-in. tube (Figure 8).

These minor corrections, accomplished without operating delays, produced a burner that not only satisfied all the conditions specified, but also resulted in a design that had advantage over the one originally contemplated.

The burner redesign has resulted in coke oven gas and 160 to 180 Btu mixed gas being effectively utilized for ingot heating with no adverse conditions or further complications. The complete transfer from one fuel gas to another can be accomplished on an operating pit in about three minutes.

OPERATING PRACTICE

The ingots heated in the pits are rolled into two categories of blooming mill product. Various size slabs are produced to be conditioned and reheated for hot rolling by the strip mill. The other product is a billet section which is directly reduced by subsequent rolling into bar stock without reheating.

The operating procedures for ingot heating have been simplified as much as possible. The initial total input rate is automatically limited to 30,000,000 Btu per hr, including the sensible heat of the recuperated air. The furnace pressure and fuel-air ratios are standardized to maintain optimum conditions and are not manipulated by the heater.

The steel is soaked out at approximately an eight to one fuel turn down and in a temperature range of 2350 to 2375 F. At this time the furnace and ingot temperatures are practically identical.

When the cover is removed for drawing, the damper automatically closes and the fuel input is blocked at the rate it was being controlled. After the cover is replaced, these controls come back into operation and maintain the preset furnace pressure and temperature during the time the ingot is being rolled.

It is our opinion that a single furnace sidewall temperature measurement is an inadequate control index for the soaking pit operation. In order to elevate furnace temperatures above the rolling temperature of the steel, this practice must rely on arbitrary time intervals based on average conditions or the heater's judgment. To determine when the steel is thoroughly soaked, it is again necessary to resort to the same means or flow meter indications. For these reasons, the installation of the equipment previously referred to for measuring the temperature of the outlet flue gases of the pits was considered advisable. Through a method of utilizing this measurement, it is possible to safely accelerate heating rates by elevated furnace temperatures and also definitely establish the time when the steel is thoroughly soaked and at optimum rolling conditions.

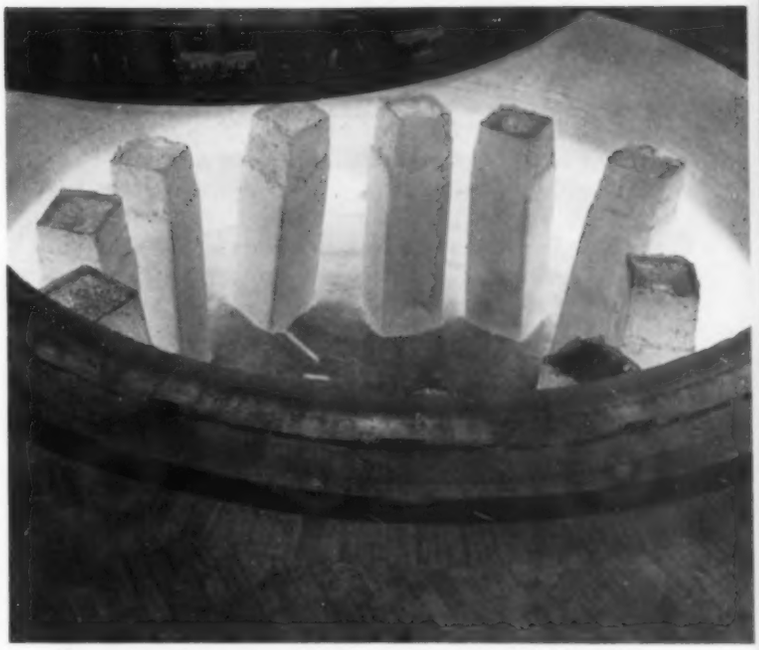


Figure 9 — Dry mill scale is used for pit bottoms.

Although the pits were equipped with the conventional arrangements for operating with coke bottoms, it had been decided in advance that a so-called "dry bottom" practice would be adopted. Therefore, no bottom makers were included in the soaking pit labor forces.

At the start of operations, the pit bottoms were filled with twelve inches of clean, dry mill scale. Since that time, it has been our experience that the replacement of between two to four in. of scale is required each month. To date it has been necessary to dig out and replace three of the bottoms, and indications are that their average operating life will be somewhere between six and nine months. In addition to the considerable savings in labor costs, the adoption of this practice has resulted in increased pit availability, reduced refractory repairs to the bottom and the elimination of such undesirable conditions as slagging and "soupy" bottoms (Figure 9).

The refractory repairs to the pits have, so far, been of a minor nature and confined principally to replacement of brick work around the sand seals and center flue rings which have been mechanically damaged. There are no indications of any serious maintenance problems developing in the near future.

SUMMARY

In conclusion, it is our opinion the ingot heating installation described demonstrates the following:

1. That it is practical to fire the circular type pit with a low calorific mixed gas and preheated combustion air.
2. If required, the transfer to an alternate fuel gas of a higher thermal quality can be accomplished without adversely affecting mill operations.

3. Tangible savings were effected through the utilization of blast furnace gas to reduce purchased fuels.
4. Advantages can be realized by proper application of a "dry bottom" practice.
5. The proper application and utilization of control equipment are vital factors in the efficient heating of ingots for maximum quality production.
6. That under similar operating conditions, our soaking pits can favorably compare with the other modern ingot heating installations in the industry.

DISCUSSION

PRESENTED BY

GRIFFIN L. ISAACS, Project Engineer, United States Steel Corp., Duquesne, Pa.

F. C. McGOUGH, Superintendent Fuel and Power Dept., Detroit Steel Corp., Portsmouth, Ohio.

E. T. TREBILCOCK, Sales Engineer, Salem-Brosius, Inc., Salem, Ohio.

B. M. PUTICH, Engineer, Bloom Engineering Co. Inc., Pittsburgh, Pa.

PAUL J. MASANZ, Combustion Engineer, Newport Steel Co., Newport, Ky.

Griffin L. Isaacs: Mr. McGough has given a clear picture of the fuel problem at Detroit Steel and a clear picture of their solution to it. I know many of us would like to use blast furnace gas as indicated by this system and it seems to me that in this plant the ultimate in fuel economy has been closely approached. I would like to know, however, why Detroit Steel chose circular type recuperative pits instead of the rectangular top-fired or bottom-fired recuperative, or even regenerative type of pits. I would also like to know the expected life of the metallic recuperators as opposed to ceramic recuperators. I know it is rather early in the life of these pits to ask the next question I have in mind, however, I was wondering what fuel rates you expect on long-range pit operations using various types of fuel.

Frank C. McGough: The final decision to install the particular type of equipment for any given steel plant operation is a major one subject to a number of considerations. In the specific case of our soaking pits, one of the determining factors that influenced this decision was our opinion that the circular recuperative pit has certain definite advantages.

Answering Mr. Isaac's second question, our experience with the metallic recuperation is, naturally, too limited at this time to make any long-range predictions as to ultimate life. However, our installation was based on factual evidence that properly engineered and controlled applications in other steel plants have equalled or bettered both the life and efficiencies of the ceramic type.

As to the third item, we did not anticipate appreciable variations in the fuel per ton figure when firing any of the fuels under similar and comparable conditions. So far, our experience has held this assumption to be true.

Griffin L. Isaacs: I would like to detail a previous question. How do circular pits affect building and service requirements? Do they require more space?

Frank C. McGough: It is generally accepted that the circular type soaking pit requires more building space per thousand sq ft of effective bottom area than the other types. However, it is very possible that this apparent disadvantage is more than offset by superior quality of heating, higher heating rates and better accessibility.

Griffin L. Isaacs: Does flame impingement on the ingot affect the temperature of the ingot to the extent that it is harmful?

Frank C. McGough: No problems of flame impingement upon the steel have developed. We do not feel this is a factor if the circular pit is properly operated and controlled.

E. T. Trebilcock: The circular soaking pit is extremely rugged in its construction and free from excessive maintenance troubles.

The tangentially fired pit is unique in that it is the only one of the modern pits that is neither square or rectangular in shape and utilizes more than one or two burners. As Mr. McGough stated, each pit is fired with ten burners located around the periphery of the combustion chamber.

The pit covers are of the dome type and consist of a heavy steel dome ring from which cast iron sand seal lip castings are suspended. The refractory in the cover is 12 in. of 2800 F insulating brick with one in. of insulating cement. The skew backs are super-duty fire brick. The weight of the insulating brick covers is approximately 60 per cent of the weight of the fire brick type.

The first dome type insulating brick cover to be installed, I believe, was at the Newport Steel Co., Newport, Ky., in 1948. This was on a 16 ft-0 in. diam circular pit. As far as I know, this insulating brick cover has given very satisfactory service.

It is true the insulating brick cover is considerably more expensive than the fire brick cover. However at the present time, the 9-in. insulating brick cover is in the picture and I believe it will prove satisfactory. The 9-in. insulating brick cover will again reduce the weight and lower the cost so that the cost will be comparable to the hard brick cover.

This decrease in weight can be taken into consideration in the cover crane design and some savings made in this respect.

There is one other item, since the subject is refractories at the moment, that will probably be of interest to circular pit users. At Detroit Steel a castable refractory is being tried in one burner tunnel in each of four pits. Four different types of castable material is being used. All the other burner tunnels are fire brick construction.

The fire brick construction is quite expensive because of the nature of the tangential tunnels and requires a lot of cutting and fitting. If the cast tunnel proves satisfactory it will mean a substantial savings in labor costs.

As Mr. McGough stated, some circular pit installations in Europe have satisfactorily utilized blast furnace gas through the recuperation of both gas and air.

There is an installation at Stewarts and Lloyds, Corby, England, that utilizes 96-Btu blast furnace gas. This installation was made in 1949. The pits are 18 ft-0 in. in diam. Needle type metallic recuperators are used for preheating both the combustion air and the

gas. The maximum gas preheat obtained is 750 F. The average is 700 F. The maximum air preheat is 1170 F. The average air preheat is 1020 F. From all reports, the circular pits at Stewarts and Lloyds are doing a remarkable job on blast furnace gas.

In conclusion, I would say that Detroit Steel has a modern pit installation. I say modern because the pits are relatively large, encased in a heavy steel shell, thoroughly insulated and have tight sealing covers. They are equipped with recuperators, pressure control, fuel/air ratio control, temperature control and are fully automatic in operation.

The burners generate a luminous flame, and the pit is designed to allow ample space for flame development while minimizing flame contact on the ingots being heated. Pressurized air is provided for combustion and fuel pressure is automatically regulated. Instruments and controls are centralized in a well lighted, glass enclosed, pressurized control house and each pit is a complete and independent heating furnace.

B. M. Putich: In his paper, Mr. McGough explained that we had some burner difficulties and that we had to make some field changes to achieve a type of burner operation which we predicted.

He also explained that we ended up with a better piece of equipment than originally furnished. We do not feel too bad about the fact that we had to make some minor changes.

This was a tough job and we realized that right from the start. We had nothing on the shelf to fulfill the specification and we had to develop an entirely new design. When you are asked to design for four different types of fuel to be fired with preheated air, it is not too difficult to miss a decimal point somewhere along the line.

On the one extreme we had to design for what is usually a slow-burning gas, namely, a mixture of blast furnace and coke oven gas having a heating value of about 150 Btu per cu ft. On the other extreme we had to design for what is usually a fast-burning gas, namely, 525-Btu coke oven gas.

On this type of pit we have had considerable past experience with high Btu gases and light and heavy oils. But up until now, we have had no experience on this type of pit with low Btu mixed gas; so naturally, in designing the equipment we were primarily concerned with the low Btu mixed gas. We realized that we had to mix the mixed gas and the preheated air very rapidly and very thoroughly to insure rapid combustion. We knew we had to burn out completely before we hit the flues; otherwise, we would be inefficient and perhaps have trouble with the recuperators.

With these facts and conditions in mind, we built the equipment we thought would do the job.

The pits were started up with a 700 Btu mixture of natural gas and air and we soon discovered that we made one mistake, and that was that we were slightly over-designed. We were completing combustion entirely too fast, creating excessive temperatures in the port blocks. We are glad that we were not under-designed, for in that case we might have been in serious trouble.

On some of the early circular soaking pit installations, we have had considerable port block maintenance caused by the extremely long port block construction. Several years ago we found a means of eliminating this difficulty almost completely. A minor change in the burner nozzle corrected this trouble in some of the older jobs.

On this particular job we feel that the pit proper around the burner level will require very little maintenance. As it worked out, the changes we had to make were very simple and we feel that we ended up with a very good job. As a result of that experience we have learned a lot. We feel that we now know more about burning low Btu gases than we ever knew before.

Griffin L. Isaacs: What material is used in the port blocks? Is it first quality fire clay?

B. M. Putich: Yes, we usually use first quality fire brick in this type of installation. In this particular case I believe a castable refractory was used.

Member: I would like to ask if the temperature lost when the cover is removed to draw the ingot for rolling is recovered? Secondly, I would like to bring up the economic feasibility of using mill scale for your bottoms. I believe that consideration of the metallic content in the mill scale plus the fact that many first-class operators like to use it as a burden on their furnace makes it doubtful whether it is practical to use this material in preference to the conventional coke breeze.

Frank C. McGough: As previously pointed out, our pit control systems were designed to minimize the heat losses from the steel when the cover is removed to draw the ingots for rolling. In view of the area exposed to radiation losses in an uncovered eighteen-ft pit, this is particularly important. Temperature differentials between the first and last ingots have presented no operating or metallurgical problems, even when steel is rapidly drawn for slab rolling.

In answer to the question regarding the economic considerations between utilizing mill scale as blast furnace burden or as a soaking pit bottom material, there is no doubt that, considering the amount of material involved, the advantages lay heavily in favor of the latter practice. The benefits of a good mill scale bottom practice over the conventional coke breeze bottoms are many and far-reaching. Among them are the elimination of detrimental "wet bottom" conditions, reduced labor and maintenance costs, and increased operational availability.

Paul J. Masanz: Newport Steel has some of these pits. I have a few questions I would like to ask Mr. McGough. Prior to this time someone brought up the question in regard to different fuel rates depending upon whether the furnaces are fired with natural gas or some other type of fuel. I did not realize that it would be difficult to give an answer to this question, and I have one a bit similar to it. I would like to have an idea of what the performance rate is on this pit, regardless of operating conditions. Just what is the fuel rate on this pit? Also, how does the fuel rate vary with standard delivery time and standard per cent of cold steel charged into the pit? I do not have any idea what the standard delivery time is. Maybe Mr. McGough will be kind enough to tell us what is the average delivery time and cold charge percentage and how his fuel input varies with a change in conditions.

The second question is relative to their success with their hard bottoms. It is necessary to have a perfectly square bottom on the ingot in order to be able to use this hard bottom? What would happen, say, if you had

a saucer-shaped bottom on your ingot, or if you maybe had a metal skirt flared out from the side of the ingot which would melt? How would those conditions affect your hard bottom?

We have found at various times that we had to crowd our pits, normally we put in 16 of our ingots. At times we found it necessary to put in a larger number of ingots in order to keep the mill operating. Just what effect does overcharging have on your pits? Has it ever been necessary to crowd your pits?

Another question pertains to the maintenance of these pits. Has Detroit Steel ever had to repair them? If so, about what period of time? Do you inspect and patch them say every month or how do you handle it? Did you have to repair the covers yet? What is the expected life of the cover and have you had any trouble whatsoever with these covers?

We know Detroit Steel has recuperators with these pits. It would be interesting to know what the expected Btu rate for the heated ingot would be without the recuperative.

Our circular pits have 12 burners. For the Detroit pits which are larger in diameter, the manufacturer has cut down to 10 burners. I would like to know why that change was made or what advantage they expect by using two less burners on these larger furnaces?

Frank C. McGough: I will try to answer Mr. Masanz's questions in the same order as he has presented them.

Assuming that any type soaking pit is properly engineered and equipped with a modern and efficient combustion system, the other factors which directly determine the amount of fuel required to heat a ton of ingots for rolling are the charging and rolling conditions. In our particular case, we have not fully developed our optimum inherent track time or maximum rolling potential. Our monthly averages are, therefore, influenced by these conditions. However, spot checks on standard charges indicate figures of 1,300,000 Btu per ton for cold steel and below 400,000 Btu per ton for steel delivered in two-hr track time.

Regarding the question as to the condition of the ingot bottoms for standing on the mill scale, we have our share of the usual charging problems resulting from dished-out stools and runouts. Every attempt is made to hold these conditions to a minimum, but a certain percentage must be considered normal operating practice.

In answer to the effects of overcharging a soaking pit, it is generally accepted that optimum pit loadings are limited to 35 to 40 per cent coverage of the effective bottom area. Excesses above these figures can only result in improperly heated ingots and increased heating times, particularly if cold steel is charged. Naturally, we make every effort to avoid this condition.

As concerns the maintenance of the pits, they are presently set up on a six month schedule for an outage to remove and replace the bottom material and make minor refractory repairs. We have had no major refractory repairs to the covers and expect it to be three to five years before it is necessary to rebuild them.

As near as we can determine, the application of recuperation to this installation results in a fuel savings of approximately 20 per cent.

Paul J. Masanz: On these covers, have you had to replace any shoes? Have you had any trouble with your covers? Around the circumference or periphery where there are a number of shoes holding the brick in place, have you had to replace any of these shoes or any of the brick because of breakage?

Frank C. McGough: I presume by shoes you mean the cover castings that are a part of the sand seal. We have had to replace a few of these that were damaged by mechanical breakage. The only refractory repairs to the covers have been an occasional replacement of skewback brick. Regarding the reason for reducing the number of burners this was due to the physical size of the hot air burner bodies and the fact it has been found that it is possible to decrease the number of burners on the circular pit and still maintain uniform heat distribution in the combustion chamber.

Bureau Publishes Analyses of Coals from 22 States and Alaska

▲ PUBLISHED records of coal analyses used by the Federal Government in awarding coal-purchase contracts are brought more nearly up-to-date with the recent issuance of a Bureau of Mines report.

Fourth in a series, the report contains analyses of 11,435 samples of coal, collected during the fiscal year ending June 30, 1953, at mine tipples and from shipments delivered to Federal departments and institutions. These analyses enabled the Government to award coal-purchase contracts on a guaranteed-quality basis, and to make price adjustments on shipments that fell below contract quality.

The Bureau of Mines maintains an open file of analyses at Washington, D. C., for the benefit of Government purchasing agents, industry, and the public. It also publishes the information as rapidly as possible so as to make it more readily available to distantly located companies that have no Washington representatives.

Analyses in the present report represent samples from mines in 22 states and Alaska. The states are: Alabama, Arizona, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky (eastern and western), Maryland, Missouri, Montana, New Mexico, North Dakota, Ohio, Oklahoma, Pennsylvania (anthracite and bituminous), Tennessee, Utah, Virginia, Washington, West Virginia, and Wyoming.

A copy of R. I. 5085, "Analyses of Tipple and Delivered Samples of Coal (Collected during the Fiscal Year 1953)" by S. J. Aresco, C. P. Haller, and R. F. Abernethy, can be obtained from the Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13, Pa. It should be identified by number and title.

By E. C. PETERSON, Engineer, Birdsboro Steel Foundry and Machine Co., Birdsboro, Pa.

performance factors affecting Bar Mill Cooling Bed Arrangement

. . . . bar mill cooling beds must be capable of handling bars from the mill runout table and have sufficient capacity to cool the production of the mill . . . . it is also necessary that the cold bar shear be capable of disposing of the cooling bars . . . . it would be very desirable and helpful in planning future installations for operators to collect field data on coefficients of friction, cooling and shearing rates . . . .

▲ A bar mill cooling bed and its associated tables and transfers must receive hot bars directly from the mill; support them with a minimum of distortion during the cooling process; and deliver them, adequately cooled and grouped, to the cold bar shear. The design of this equipment is complicated and many solutions are available, depending on the straightness desired in the finished product, the mill delivery speed, sizes to be handled, and the funds available. Complete mechanization is usually assumed. The cost is high, amounting typically to 45 per cent of the cost of an entire modern bar mill installation, considering mechanical equipment only.

The design features of these beds are largely the concern of the equipment builder and as long as the equipment furnished will perform its essential function reliably and without excessive maintenance, the mill operator will be content.

There are several factors, however, which are outside the province of mechanical design and which relate the bed to the rest of the mechanical equipment. These factors have a direct bearing on how well the bed will serve the mill. They must be considered in the light of what the mill is expected to do, and they should be examined, therefore, by the operators, when a new installation is being planned. It is with three of these factors that are most commonly discussed that this paper will be concerned.

1. Ability of the bed to discharge bars from the mill runout table.
2. Ability of the bed to cool the mill production.
3. Ability of the cold bar shear to dispose of the cooled bars.

Modern, high-speed bar mills show a relatively long length of table between the flying shear and the cooling bed proper. At first glance this table appears to accomplish nothing but unnecessary elongation of the mill building, and there is always pressure, therefore, from the people who are spending the money, to keep the length of this table to a minimum. On this table, however, there is often some split second timing

Figure 1 — Typical mill runout table consists of motor mounted rollers and close fitting aprons.

Figure 2 — This table has two types of kick-off.

Figure 3 — A double bed table reduces need for acceleration and split-second timing.

Figure 4 — This kick-off device has sweep arms with replaceable tips.

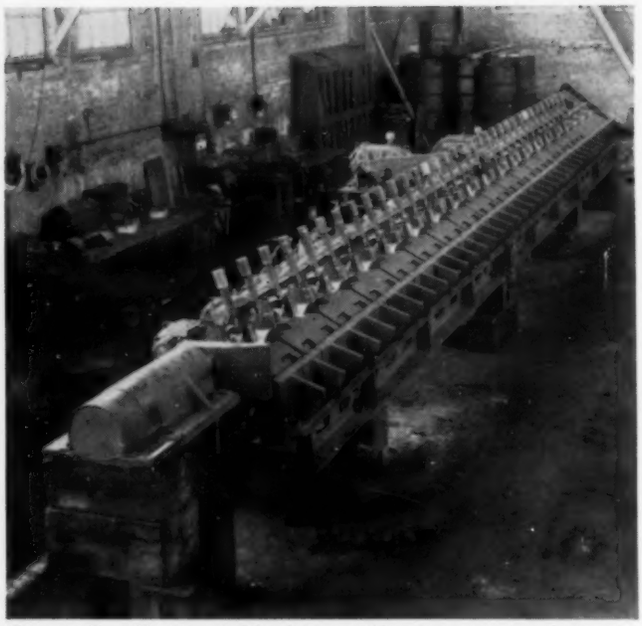


Figure 5 — Runin table has stationary aprons between table rollers.

required, and the finishing mill speed can be seriously limited by placing the cooling bed entrance too close to the flying shear, especially when a single bed is used.

As the flying shear cuts cooling bed lengths from the bar leaving the finishing stand, it is the function of the mill runout table to accelerate each length to obtain separation between the rear end of the cut off bar and the front end of the following length. At the point of kick-off, this acceleration must have produced sufficient separation between the two bars to permit the kick-off device to act on the leading piece without affecting the following one. There must also be sufficient distance and time available for the discharged bar to come to rest before being transferred to the cooling bed proper, and this discharge to the cooling bed must be accomplished before the succeeding piece is kicked off of the cooling bed runin table.

The mill runout table is a simple affair, with motor mounted rollers and close fitting aprons; a typical example is shown in Figure 1. The motors are connected to a variable voltage, d-c generator, or to a variable frequency alternator to permit speed variation.

The kick-off may be of several types, but it is essential that it perform its function rapidly and clear the table for the following bar. Two types of kick-off are shown in Figure 2. The lower table has kick-off arms which traverse across the runin table above the level of the rollers and return beneath the level of the aprons to starting position. Shaped paddles at the top are used to minimize interference of these arms with the leading edge of the entering bar. On the upper table rotating paddles are used, suitable for short strokes and small bars. Both of these devices are relatively rapid in their operation and are suitable, therefore, for mills with flying shears and single beds.

Where funds are available for a double bed, such as shown on Figure 3, the need for acceleration and split-second timing is avoided by delivery of each succeeding cut length to an alternate side of the bed. In such cases a kick-off device, as shown on Figure 4 can be used. Sweep arms with replaceable tips carry the bar across the table. This kick-off is slower than the previous devices in clearing the table, but is less critical in operation because of the more continuous surface presented to the leading edge of the bar.

Deceleration and kick-off must commence as soon as adequate separation has been provided for the operation of the kick-off device. On slow finishing mills, it is sufficient to allow the bar to drop off the runin table and to slide to a stop in an adjacent trough. Such a runin table, with stationary aprons between the runin

Figure 6 — Bar is shown during acceleration part of travel.

Figure 7 — Bar is shown at deceleration part of travel.

table rollers is shown in Figure 5. On high-speed mills, however, the time immediately before and during kick-off is too valuable to be lost for deceleration and a table with lifting aprons is used. Figure 6 shows the bar traveling on a cooling bed runin table during the acceleration part of its travel. Figure 7 shows this same runin table with the aprons raised prior to kick-off, thus commencing deceleration of the bar at the earliest possible moment.

The time required for the functioning of mechanical kick-off devices can be controlled and predicted. A kick-off device such as shown on the lower table on Figure 8 can be made to clear the runin table within 0.5 sec after contacting a bar for kick-off. A kick-off device such as shown on the top table of Figure 8, can be made to clear the runin table within 0.33 sec after contacting the bar for kick-off.

The nebulous factor in all of these calculations is the coefficient of friction in acceleration and deceleration. As in most cases where friction is dealt with under various conditions, this coefficient varies widely, and design figures must be conservatively chosen from available data, with adequate allowance for possible variations. Some typical figures for these coefficients, as observed on a runin table of the design shown in Figure 7, are presented in Table I.

These coefficients of acceleration were developed from stop watch measurements of front and rear end travel of bars, except when a flying parting shear was used, when the relative travel of front and rear end were computed from photographic measurements.

The coefficients of deceleration were taken from observed distances of slide.

The wide disparity between coefficients of acceleration and deceleration is probably explained by the fact that a very small area of contact is obtained between rollers and bar during acceleration; by contrast a large area of contact is obtained between aprons and bar during deceleration. Variations in the coefficients of deceleration are not so readily explainable. The effect of unknown variables on the performance of the bed indicates the need for conservative design factors.

Figure 8 — Kick-off device shown can be made to clear the runin table within one-half second. The kick-off device on the top table can be made to clear the runin table within one-third second.

The solution of any runout table problem must, of course, be based on the speeds and mechanism which are to be used. An analysis of a typical and critical case

TABLE I

Mill designation	Section being rolled	Mill delivery speed, fpm	Runout table speed, fpm	Coefficient of friction in acceleration	Coefficient of friction in deceleration
12 in. Bar	$2\frac{15}{16}$ in. diam rounds	389	848	0.12	0.26
12 in. Bar	$2\frac{5}{8}$ in. diam rounds	....	848	....	0.41
12 in. Bar	$1\frac{1}{4}$ in. diam rounds	522	870	0.10	0.64
12 in. Bar	$2\frac{1}{32}$ x $1\frac{5}{16}$ in. flats	560	895	0.11	0.61
10 in. Bar	$\frac{7}{8}$ in. diam deformed bar	1700	2715	0.10	0.40
10 in. Bar	$1\frac{1}{4}$ in. hex	1290	1650	0.08	0.21
10 in. Bar	$1\frac{1}{16}$ in. diam rounds	1250	2600	0.12	0.29
10 in. Bar	$2\frac{1}{2}$ x $\frac{5}{16}$ in. flats	1350	2550	0.15	0.40

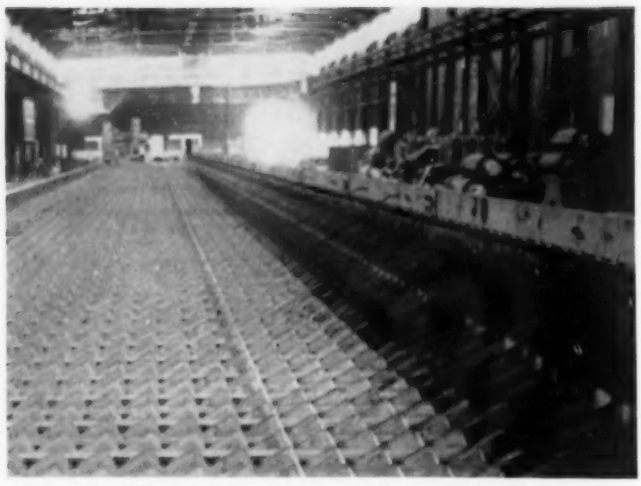


Figure 9 — Runout table shown is located after a rotary drum flying shear.

will help to illustrate the magnitude and relation of the factors involved. We will assume a runin table, similar to that shown in Figure 9. The runout table follows a rotary drum flying shear. Lifting aprons decelerate the bar on the runin table, and a paddle bar kick-off is used. The bed is single and the bar is continuously accelerated by the runout table up to the point of contact with the lifting aprons in order to obtain maximum separation from the leading end of the following bar. The minimum condition to be met is that the back end of the bar being

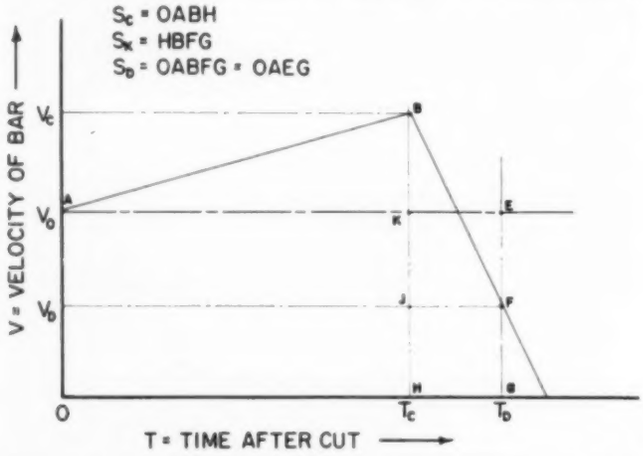


Figure 10 — Diagram shows speed and displacement relationships for runout table.

discharged from the runout table shall not be overtaken by the front end of the succeeding bar until the first bar has left the table. Actually this type of kick-off mechanism will permit some overlap, but the stated limitation should be met in design consideration. The speed and the displacement relationships are shown graphically in Figure 10. In this diagram the horizontal scale represents time intervals after cutting at the flying shear, the vertical scale represents bar velocity, and the area enclosed represents distance traveled from the flying shear. Definitions of the symbols follow:

S_d = Distance traveled from front end of oncoming bar from mill at time of discharge of parted bar from table, in feet.

S_c = Distance traveled by rear end of parted bar, at point of contact with lifting aprons, in feet.

S_k = Distance traveled by rear end of parted bar during period from contact with lifting aprons to discharge from table, in feet.

V_o = Mill delivery speed, in ft per sec.

V_c = Velocity of cut bar at time of contact with lifting aprons, in ft per sec.

V_d = Velocity of bar at time of discharge from runout table, in ft per sec.

T_c = Time interval between cutting of bar at flying shear and contact with runout table lifting aprons, in sec.

T_d = Time interval from parting of bar at flying shear to discharge from runout table, in sec.

$T_k = T_d - T_c$ = Mechanical cycle time between lifting of runout table aprons and completion of forward stroke of kick-off bars, in sec.

d = Rate of deceleration in ft per sec per sec.

a = Rate of acceleration in ft per sec per sec.

U_d = Coefficient of friction in deceleration.

U_a = Coefficient of friction in acceleration.

F = Force of acceleration of deceleration.

W = Weight of parted bar.

M = Mass of parted bar.

When $S_d = S_c + S_k$ the minimum condition for satisfactory kick-off performance, as stated above, is met. Therefore:

(1) $S_d = S_c + S_k$

(2) $S_c = V_o T_c + \frac{(V_c - V_o) T_c}{2}$

(3) $S_k = (T_d - T_c) V_d + \frac{(V_c - V_d)(T_d - T_c)}{2}$

(4) $S_d = V_o T_d$

(5) $V_o T_d = V_o T_c + \frac{(V_c - V_a) T_c}{2} +$

$(T_d - T_c) V_d + \frac{(V_c - V_d)(T_d - T_c)}{2}$

(6) $2V_o T_d = V_o T_c + T_d V_d - T_c V_d + V_c T_d$

(7) $T_k = T_d - T_c$

(8) $T_c = T_d - T_k$

(9) $V_c - V_d = T_k d$

(10) $V_d = V_c - T_k d$

(11) $V_c - V_o = (T_d - T_k) a$

(12) $V_c = (T_d - T_k) a + V_o$

Substituting (8) and (10) in (6), we get:

(13) $2 V_o T_d = V_o (T_d - T_k) + T_d (V_c - T_k d) - (T_d - T_k)(V_c - T_k d) + V_c T_d$

Substituting (12) in (13), we get:

(14) $T_d^2 a = T_k^2 a + T_k^2 d$

(15) $T_d = T_k \sqrt{1 + \frac{d}{a}}$

(16) $S_d = T_d V_o$

(17) $S_d = V_o T_k \sqrt{1 + \frac{d}{a}}$

From the basic acceleration formula:

$$(18)\quad d=\frac{F}{M}=\frac{W\ U_d}{M}=\frac{32\ M\ U_d}{M}=32\ U_d$$

Similarly

$$(19)\quad a=32\ U_a$$

$$(20)\quad S_d=V_o\ T_k\sqrt{1+\frac{Ud}{Ua}}$$

Using expression (20) for a typical example where:

$V_o=33.3$ fps (2000 fpm)

$T_k=0.5$ sec

$U_d=0.25$

$U_a=0.10$

we find that $S_d=33$ ft.

It may be pointed out that S_d could be decreased by decreasing T_k. To accomplish such a reduction, the speed of kick-off operation must be increased. In practice these motors are usually slowed down to avoid abrupt kick-off of light bars at high speed, with attendant danger of cobbling. Also the lift aprons might be eliminated to decrease the value of U_d during kick-off. It should be considered, however, that discharge from the runout table at high speeds is a critical operation and further that considerable distance is consumed by deceleration itself.

Figure 11 — Kick-off facilities are often needed well ahead of the bed proper.

From the above expressions we may develop:

$$(21)\quad V_d=32\ T_k\ (U_a\sqrt{1+\frac{U_d}{U_a}}-U_a-U_d)+V_o$$

And solving it for V_d the velocity of the bar at time of discharge, we find it to be 27.4 fps — a very respectable speed at which to be pushing around a thin, hot bar.

We may also use the formula:

$$(22)\quad S_s=\frac{V_d^2}{64\ U_d}$$

where S_s=length of slide after discharge, in feet, to find that in our example the bar will slide 47 ft in the straightening notch before stopping, or a total travel of the back end of the bar of 80 ft from the flying shear. If lift aprons were not used deceleration during kick-off would be caused by contact with the kick-off paddles only, and it would be substantially reduced. Assuming accelerating friction of rollers to equal decelerating effect of kick-off bars in this case, we get constant velocity during kick-off.

Turning again to the velocity relationships of Figure 10, we can also develop expression:

$$(23)\quad V_c=32\ U_a\ T_k\left(\sqrt{1+\frac{U_d}{U_a}}-1\right)+V_o$$

for velocity at point of contact with kick-off. In our example this figure becomes 34.9 fps.

For this example we also need expression:

$$(24)\quad S_c=T_k\left(\sqrt{1+\frac{U_d}{U_a}}-1\right)\left(V_o+32\ U_a\ T_k\left(\sqrt{1+\frac{U_d}{U_a}}-1\right)\right)$$

which gives us $S_c=15.2$ ft.

During the kick-off period of 0.5 sec the bar will travel another $34.9\times 0.5=17.4$ ft.

Expression (22) tells us that $S_s=76.2$ ft, for a total travel of the back end of the bar from the flying shear of 108.8 ft. This indicates a theoretical saving of 28.8 ft in length of runout table required if lifting aprons are used.

These figures also point out the need for kick-off facilities well ahead of the bed proper, as shown in Figure 11, if use is to be made of the entire length of the bed.

We should consider briefly in passing the effect of cooling bed length on the functioning of the kick-off and transfer mechanisms. With a 260-ft bed, receiving 240-ft long bars at a rate of 1800 fpm, or 30 fps, the kick-off and transfer mechanisms must operate every 8 sec. If funds are available for a 500-ft bed, on the other hand, and 480-ft bars can be handled at the same rate of speed, a time cycle of 16 sec is involved. The shorter time cycle is by no means impossible. In fact, Figure 12 shows two strands running simultaneously at a delivery speed of 1500 fpm onto a 265-ft long bed, giving a time cycle of 4.9 sec. However, it can readily be appreciated that the shorter time cycle becomes more critical in its adjustment and operation, and the bed itself is, of course, subject to considerably more wear and tear.

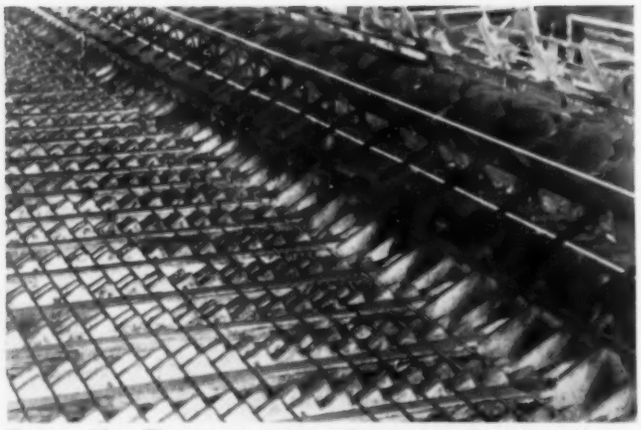


Figure 12 — Two strands are shown running simultaneously at delivery speed of 1500 fpm.

Before leaving the subject of runout tables, it may be of interest to examine Table II, showing some typical mill sizes, delivery speeds, and lengths of runout table for single beds with flying parting shears. It should be pointed out that these tables may not all have been calculated for minimum kick-off conditions, but their length may have been dictated by other considerations.

TABLE II

Mill designation	Approximate maximum delivery speed, fpm	Length of runout table, ft
12½-10½ in.	1200	63
18-14 in.	1300	58
10 in.	1360	123
14 in.	1300	58
10 in.	1800	103
11 in.	1800	170
10 in.	2000	126
10 in.	1500	65
12 in.	1500	127
10 in.	1400	62

Let us turn now to the second question which is often raised by mill operators when a cooling bed installation is being considered, that is, the question of cooling capacity.

The principal function of the cooling bed proper is to hold the bars straight during the cooling process until they have had time to become stiff so as to resist bending during handling. In addition, the cooling bed should usually hold the bars separate from one another, which, in turn, promotes uniform cooling and straightness and also permits the bars to cool in a reasonable length of time. In some mills rolling highly alloyed steels, it is a metallurgical requirement that the bars be held separate during the cooling period until some pre-determined temperature is reached, in order to avoid variations in properties due to differential cooling, which occurs when the bars are permitted to come into contact with each other. At other times, bars are to be slow cooled and a bed which can hold them together for the operation of pack annealing is required.

The machinery used for accomplishing these ends generally resolves itself into a series of notches. In sloping beds, gravity may be used to feed the bars from notch to notch and in horizontal beds, which are more

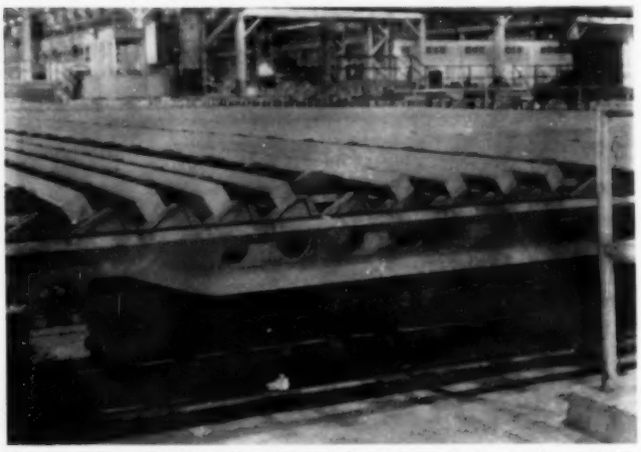


Figure 13 — Alternate sets of bars are balanced against each other.

common recently, various oscillating arrangements of the notch bars are used to transfer the bars horizontally from notch to notch. One set of bars may be stationary, while the other oscillates, transferring the bars one notch forward on the stationary bars with each oscillation. In the mechanism shown in the lower portion of Figure 13 all bars are oscillating and are arranged in such a manner that each alternate set of bars is balanced against the other, so that the cooling bed drive motors have only to lift the bar load and not the bed mechanism. This arrangement promotes smoothness and rapidity of operation. In addition the notch bars may be set so as to rotate round bars on the bed slightly with each oscillation; thus, improving uniformity of cooling and straightness.

Typical cooling times are shown in Table III. It should be noted that the 12-in. mill cooling bed in the

TABLE III

Bar size, in.	Mill designation	Mill finishing temp F	Time from leaving finishing stand to loss of visible glow, min (approx 1100 F)	Time from leaving finishing stand to discharge to shuffle bars, min	Temperature at delivery to shuffle bars, F
1¼ Round	12 in. (Fig. 17)	1700	....	8.7	930
2⅝ Round	12 in. (Fig. 17)	1800	....	19.0	1100
2 15/16 Round	12 in. (Fig. 17)	1880	22	20.6	1100
2 1/32 x 1 5/32 Flats	12 in. (Fig. 17)	1825	11	10.7	950
3 x ⅞ Flats	12 in. (Fig. 17)	1850	....	11.3	925
1¾ x 0.214 Flats	10 in. (Fig. 3)	1875	....	9.3	850
1¼ Hex	10 in. (Fig. 3)	1925	8	9.1	800
1 Round corrugated	10 in. (Fig. 3)	1930	5	7.4	650
1 1/16 Round	10 in. (Fig. 3)	1925	4	7.5	750
No. 7 Re-bar	10 in. (Fig. 3)	1900	6.5	9.3	650

above tabulation was ventilated from below by a 10-hp fan.

Mr. Udall, in his excellent paper, Cooling Beds for Bar Mills, in the Journal of the Iron and Steel Institute, November, 1951, showed a theoretical cooling curve, with horizontal scale representing time over the ratio of bar weight to surface area. We can adapt this curve for general conditions and apply our figures by leaving the horizontal scale blank, as shown in Figure 14. Cooling times from Table III may be marked on the horizontal scale to intersect the curve at the corresponding temperature; with a time scale thus established, cooling times to any specified temperature may be approximated, for the specific conditions of available data.

If a maximum temperature which is acceptable at discharge to the shuffle bars is specified, an indication of the width of bed necessary can be found from the table and curve.

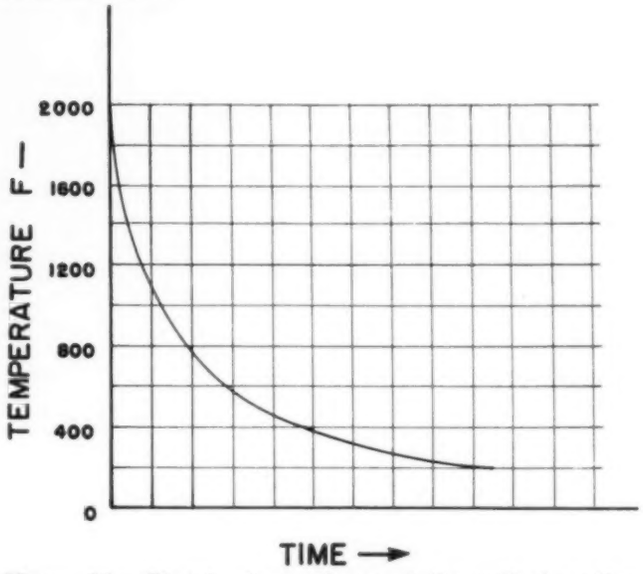


Figure 14 — Sketch shows shape of theoretical cooling curve.

For example if, for metallurgical reasons, 2 15/16-in. rounds are to be cooled to 600 F before discharge from the bed, a time of 20.6 min corresponding to a temperature of 1100 F from Table III may be established. We may then estimate a cooling time of 56 min. If a production of two bars per min is anticipated, then a bed with provision for 110 bars must be provided, allowing one on the runout table and one in the straightening notch.

This method of developing cooling capacity is quite approximate, but may be considered satisfactory for most cases in view of the following factors:

1. Temperature data to construct a complete cooling curve are difficult to obtain under actual mill operating conditions.
2. Experimental data must be questioned unless elaborate steps are taken to insure conditions parallel to those to be found in the field.
3. Field conditions vary so much from mill to mill that the performance of a new installation will be only approximately the same as any present installation.
4. Cooling performance of beds is rarely specified in any but the most general terms.

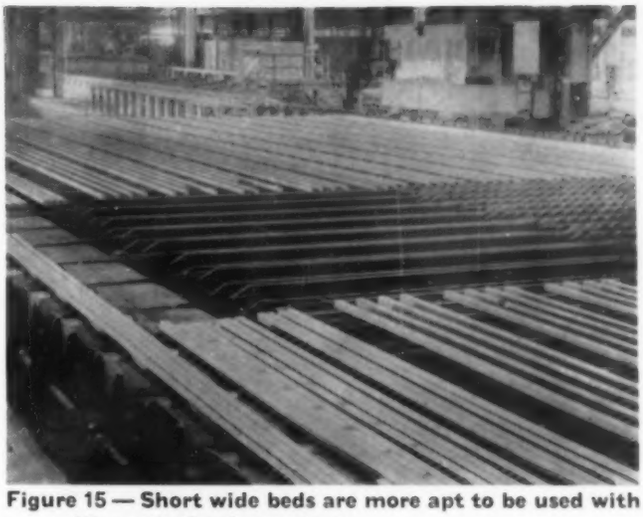


Figure 15 — Short wide beds are more apt to be used with mills producing heavy bars.

The required space can be provided, by various combinations of length and width, and will be determined by bar lengths desired, mechanical design considerations, and space limitations. Several rows of short bars may be placed in parallel on the bed. Generally speaking, high-speed mills rolling smaller sizes have long, narrow beds, whereas slower speed mills producing heavy bars are more apt to use a short, wide bed, as shown in Figure 15. For billets and slabs, where straightness is not too much of a problem, a skid bed with retracting dogs, as shown in Figure 16, may be used successfully. Table IV is a tabulation of various beds, giving their lengths and notch capacity.

The long beds required to handle the product of modern high-speed mills in sizes up to 2½-in. rounds provide more than ample cooling capacity with beds of minimum practical width. In larger mills producing sizes from 3-in. diameter and up, cooling capacity is often the determining factor in bed width.

The third factor in cooling bed performance that we will consider is the capacity of the cold bar shears. Mill delays due to filling up of the cooling bed are often encountered. Therefore, the shearing facilities deserve serious consideration. Certain sizes and shapes give more difficulty than others, but the real nub of the problem usually lies in the lengths to be sheared. If orders are to be sheared directly to length on the mill

Figure 16 — Skid beds with retracting dogs can be used with billets and slabs.

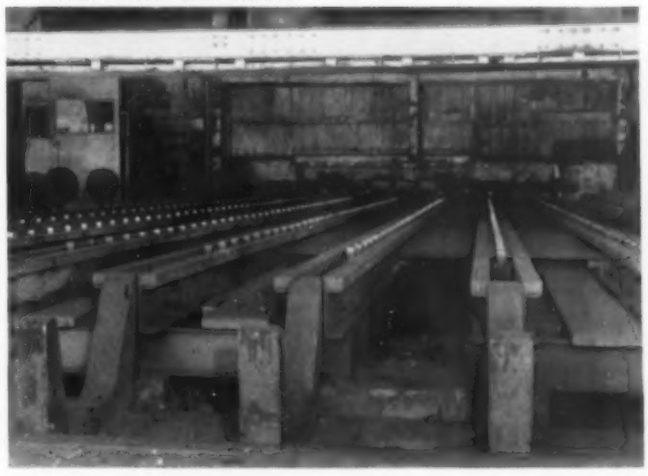


TABLE IV

Mill designation	Maximum size handled[4], in.	Length of bed, ft-in.	Width of bed centerline of runin table to centerline of shear table, ft-in.	Maximum tons per hour
26-in. Mill	5-in. Diam	135-5	55-1	100 (4 in. Sq)[1]
22-in. Mill	5-in. Square billets 2 x 16-in. Slabs	32-0	78-10	55 (4-in. Sq)[2]
21-in. Mill	7½-in. Diam	135-5	39-11	65
18 x 16-in. Skelp mill	16 x ¾-in. Sheet bar	161-6	34-0	44
18 x 14-in. Mill	4-in. Diam	200-0	35-2	60 (4⅜ x 1⅞ in.)
18 x 14-in. Mill	4½-in. Diam	123-0	39-11	Not available
18-in. Mill	4½-in. Diam	123-0	39-8	Not available
18-in. Mill	5-in. Square 5½-in. Diam	33-0	31-3	Not available
16 x 12-in. Mill	3-in. Diam	243-4	19-6	92 (No. 11 Re-bar)[5]
16-in. Mill	2½-in. Diam	70-0	20-7	Not available
16-in. Mill	5-in. Square 5½-in. Diam	32-0	10-6	50 (7-in. Diam)[2]
14-in. Mill	2½-in. Diam	251-8	18-5	Not available
12½ x 10½-in. Mill	2½-in. Diam ¾ x 4½-in. Flats	240-0	18-4	45 (2½-in. Diam)
12 x 10-in. Mill	2½-in. Diam	251-8	18-5	Not available
12-in. Mill	1⅝-in. Diam 1 x 2-in. Flat	130-0	18-4	15
12-in. Mill	2½-in. Diam	228-0	17-0	80 (2½-in. Diam.)[2]
12-in. Mill	2½-in. Diam	257-0	16-9	60[2-3]
12-in. Mill	Not available	30-0	30-3	Not available
12 x 10-in. Mill	2½-in. Diam	241-8	14-3	Not available
11-in. Mill	2½-in. Diam	260-0	18-7	33 (1¼-in. Diam)[3]
10-in. Mill	1⅞-in. Diam ½ x 4-in. Flats	255-0	16-4	Not available
10-in. Mill	2½-in. Diam	197-5	15-9	50 (1-in. Diam)
10-in. Mill	1½-in. Diam	394-0	18-4 (Double)	95 (1⅝-in. Diam)
10-in. Mill	2½-in. Diam	253-0	15-9	44 (1-in. Diam)
10-in. Mill	2½-in. Diam	107-6	15-9	Not available
10-in. Mill	2½-in. Diam	306-0	17-6	Not available

[1]7⅜-in. Sq at 125 tons per hr too hot to saw and handle. [2]Redness in bars at shear. [3]Turn average.
[4]Per original design. [5]Bars two per notch — red glow and soft coming off bed.

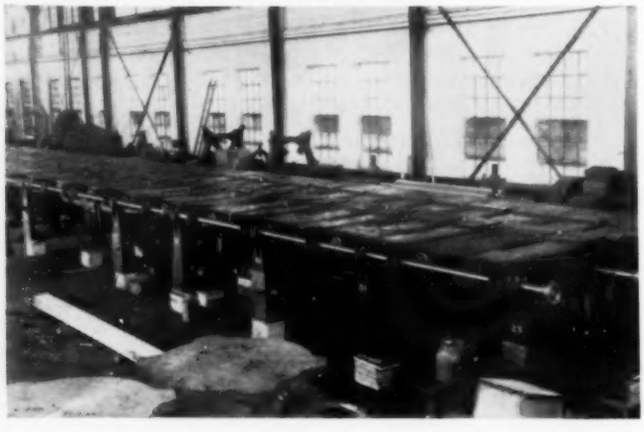
shears and these lengths are less than 25 to 15 ft, depending on mill speed and shearing capacity available, difficulty will probably be encountered in handling the mill output. Against the losses due to mill delays must be set the cost of re-shearing to order length, and the way in which the mill practice is set up should be decided after a cost analysis.

From a cooling bed application standpoint, however, we are interested in the ways in which adequate shearing capacity can be provided at a minimum expense; and several possible arrangements may be mentioned.

1. The simplest arrangement is a single bed with a single cold bar shear, as shown in Figure 17. Such an arrangement suffices adequately for low speed mills, generally those producing bars in the larger size ranges. Even here, unless the shears are of unusually large capacity, the heavy bars will choke the shear because only two or three bars can be cut at a time.
2. Double bed as shown in Figure 3. One of the principal reasons for installing a double cooling bed is that it provides two shear outlets.
3. A single bed with double shear approach table, transfer, and two bar shears, as shown in Figure 18. This arrangement provides two shear outlets without the additional great expense of a double bed. In order that the two shears may be fed without interfering with each other, it is necessary to pro-

Figure 17 — Layout shows simplest arrangement for single bed with single cold bar shear.

Figure 18 — This layout uses a double shear approach table, transfer and two bar shears.



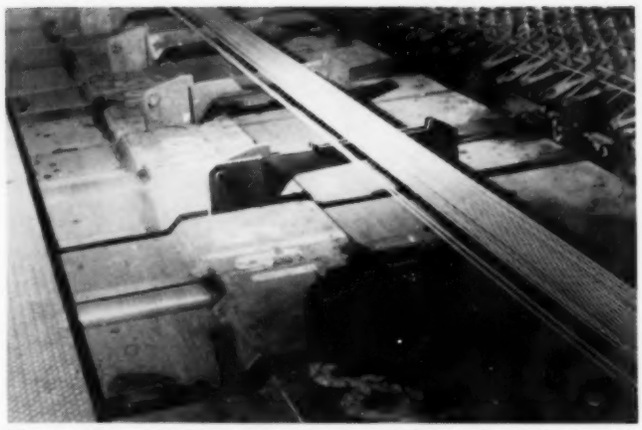


Figure 19 — Lift-over transfer is used for single bed with double shear approach table.

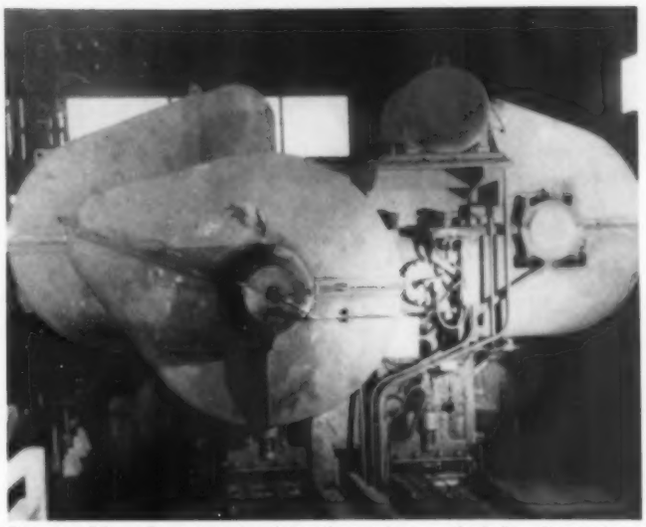


Figure 20 — Special double shear is needed for layout of Figure 19.

vide a long runout table from the cooling bed to the first shear, so that, while this shear is handling a lift of bars, the cooling bed itself may be clear for transfer of an additional lift to the second shear approach table.

4. Single bed with double shear approach table and lift-over transfer, as shown in Figure 19. With this arrangement two parallel tables directly opposite the bed can feed two shears without interference, since the lifts for the second shear can be passed over the top of those for the first shear. This arrangement provides an outlet to two shears without requiring a long runout table. Since the shears come close together, a special double shear is required, as shown in Figure 20.

Figure 21 — Two gage heads on the shear gage table finds one normally used for gaging and one as an adjustable stop.

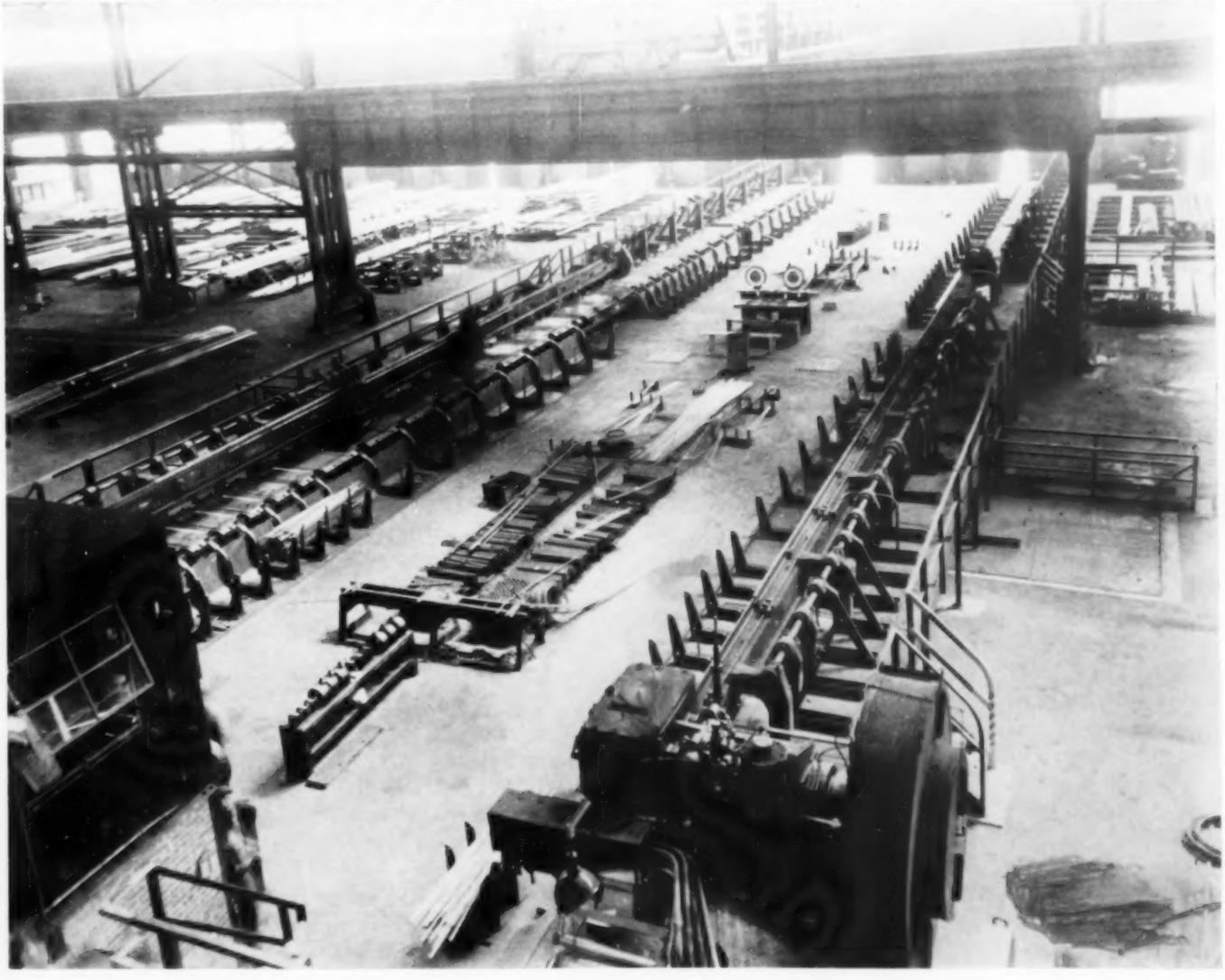


TABLE V

Section being cut	No. of bars being cut together	Length of bars being cut, ft-in.	Length, in. and type of blade	Time per cut, min	Extra time for each group of bars, min
2 x 1 13/16-in. Flats	5	35-5	30—Flat	0.30	1.1
1 1/4-in. R.C. square	15	35-0	30—Flat	0.20	2.0
1 7/32-in. Rounds	12	35-0	30—Grooved	0.30	1.6
2 1/8-in. Rounds	7	20-0	30—Grooved	0.18	5.7
2 1/8-in. Rounds	7	34-6	30—Grooved	0.55	4.2
2 5/8-in. Rounds	3	40-6	30—Grooved	0.50	1.0
2 5/8-in. Rounds	3	20-0	30—Grooved	0.20	1.8
2 15/16-in. Rounds	3	38-6	30—Grooved	0.50	0.7
1 x 3/8-in. Flat	13	16-0	36—Flat	0.20	1.0
1 1/2 x 1/8-in. Angle	12	20-0	36—Grooved	0.30	2.5
2 1/2 x 0.0262-in. Flat	12	23-0	36—Flat	0.20	2.3
2 1/2 x 5/16-in. Flat	11	50-0	36—Flat	0.40	1.6
1 1/4-in. Hex	7	33-0	36—Grooved	0.50	2.3
1 1/16-in. Rounds	12	32-6	36—Grooved	0.35	3.0
7/8-in. Deformed bar	13	60-0	36—Flat	0.45	4.3

Beyond the shear should be a long shear gage table with two gage heads — one generally used for gaging and one as an adjustable stop — to permit the rapid removal of sheared material to the cradles and from the cradles without delaying the shear. A typical unit shown in Figure 21 is 149 ft long.

The tabulation in Table V of average shearing times, made from observations under actual operating conditions, may be helpful in giving some indication of the quantity of material that can be processed by a cold bar shear.

The additional time between lifts of bars includes moving a lift from the cooling bed down to the shear, lining up the front ends, taking the crop cut, and clearing the table of rear end crops, ready for the next lift.

To see how much tonnage could be handled by a shear for a certain condition, we can write the following expression:

$$(25)\quad \text{Tons per hr} = \frac{NLSW}{(T_c\ S + T_L)\ 33.33}$$

Where:

T_c = Time per cut, in min.

N = Number of bars per lift.

T_L = Additional time between lifts, in min.

L = Length to be cut, in ft.

S = Number of lengths cut per lift.

W = Weight per ft of bars, in lb.

As an example we may consider 1 × 3/8-in. flats, being cut on 36-in. long flat blades into lengths of 16 ft, with 13 bars per lift being sheared at once from lifts cutting into 13 lengths. Using expression (25) above, we get a figure of 28.6 tons per hr.

In conclusion, it is seen that rational solutions of three factors in cooling bed performance, are possible. The accuracy of these solutions depends in large measure upon the availability of field observations made under conditions which closely parallel the proposed installation. Presented herein are some measurements which have been taken, necessarily at random, through the courtesy of a mill operator. It would be very beneficial for the technology if more such data concerning coefficients of friction, cooling rates, and shearing rates could be collected and made available in future papers, by members of the AISE having regular access to cooling bed operations.

EFFECTIVE WAY FOUND TO COMBAT SLUDGE IN NO. 6 FUEL-OIL TANK

▲ HOW the Bureau of Mines found a simple way to prevent too much sludge from gathering at the bottom of No. 6 fuel-oil storage tanks is told in a report released by the Secretary of the Interior. No. 6 (Bunker C) fuel oils, which are the most inexpensive refinery products, almost always contain some dirt and water. The dirt is made up chiefly of particles of carbon and can be burned without trouble if there is not too much of it in the oil. After a tank is filled, however, dirt normally settles to the bottom within a few days, forming a sludge that builds up with repeated fillings, often seriously reducing the capacity of the tank as well as clogging strainers and causing trouble with fuel pumps and burners.

Through a combination of laboratory studies and tests at Government boiler plants, the Bureau learned that if the bunkering (or filling) pipe opens near the bottom of a tank, incoming oil will stir up the sludge during every filling. If the suction opening is also near the bottom, the suspended sludge will be carried to the burner where it can be burned with no difficulty.

As an illustration, the report tells how controlled bunkering was tried at a Government plant to eliminate the need for an expensive tank-cleaning job. The operator had requested a $10,000 allotment for sludge removal, but instead, a special pipe, discharging near the bottom of the tank, was installed in the fill-hatch at a cost of $25.

At the end of a year, it was found that enough of the sediment stirred up by oil flowing against it from this pipe during every filling had been drawn to the burners so that the usable depth of the tank had been increased by 10 in. and its capacity by about 7,000 gal. Meanwhile the sludge stirred into the oil had been burned without difficulty.

A copy of R. I. 5113, "The Sludge Problem in No. 6 Fuel-Oil Tanks," by J. F. Barkley, G. L. Hopps, and A. A. Berk, can be obtained from the Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13, Pa. It should be identified by number and title.

Pre-Attack Planning for Industrial Defense

By W. R. RAMSAY,

Industrial Defense Coordinator, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

. . . . the American Iron and Steel Institute and the Department of Commerce have published a manual for industrial defense of steel plants . . . . this manual warrants detailed study by all steel plant officials . . . . after allowing for local conditions, all plants should prepare standby plans for operation and repairs after enemy attack . . . .

▲ IN discussing some of the problems involved in pre-attack planning for industrial defense, it is recognized by the military that if there is a Third World War, the battlefield may well be in our cities. That, of course, would mean a direct attack upon our plants. The scope of the problem has changed materially since World War II because:

1. Our potential enemy now has long range bombers which can deliver an atomic attack and return to their bases.
2. The extent of damage which can be inflicted by one bomb is so widespread that many plants could be seriously damaged simultaneously.
3. The advent of guided missiles increases the potential hazard to our communities.

Hence, it is evident that for the first time in American history, we are faced with a problem of preparations for an attack on industry which could come without advance notice. If such an attack should occur, it would tax the ingenuity of our industrial management to return quickly to the production capacity for the war effort which would be vitally needed overnight. Even with the most careful planning for rehabilitation, our job would be of much greater magnitude than any our great American industry has so successfully accomplished in the past. Pre-attack planning for industrial defense thus means that we must study the problems involved in reducing the efforts of an enemy attack upon our plants and make a thorough analysis to determine the best methods to rehabilitate employees, the equipment, buildings and other plant facilities.

Industry a part of the community — It is well recognized that industry is a definite part of a community, whether in peace or war. One cannot exist without the other. Industry is proud to be located in a good community and in order for citizens in the community to live successfully, they must have progressive industry that provides sufficient jobs to create a well-balanced relationship. Hence, in time of enemy attack, a disaster in a community would affect industry, the employees, stockholders, women, children, churches—in fact, everyone would be affected to a greater or lesser degree.

The first part of this paper will outline briefly the community problem of pre-attack planning and then

TABLE I

Atom and Hydrogen Bomb Destruction

Atom bomb . . . . . $2\frac{1}{2}$ **x or 50,000 tons of Tnt equivalent**

Hydrogen bomb . . . . . **10,000,000 to 15,000,000 tons of Tnt equivalent**

Areas of Destruction

	Atom bomb	Hydrogen bomb (1954)
Total destruction-radius, miles	$\frac{1}{2}$	4
Severe damage-radius, miles	1	8
Moderate damage-radius, miles	$1\frac{1}{2}$	14
Partial damage-radius, miles	2	16
Limit of incendiary action-radius, miles	$2\frac{1}{2}$	25

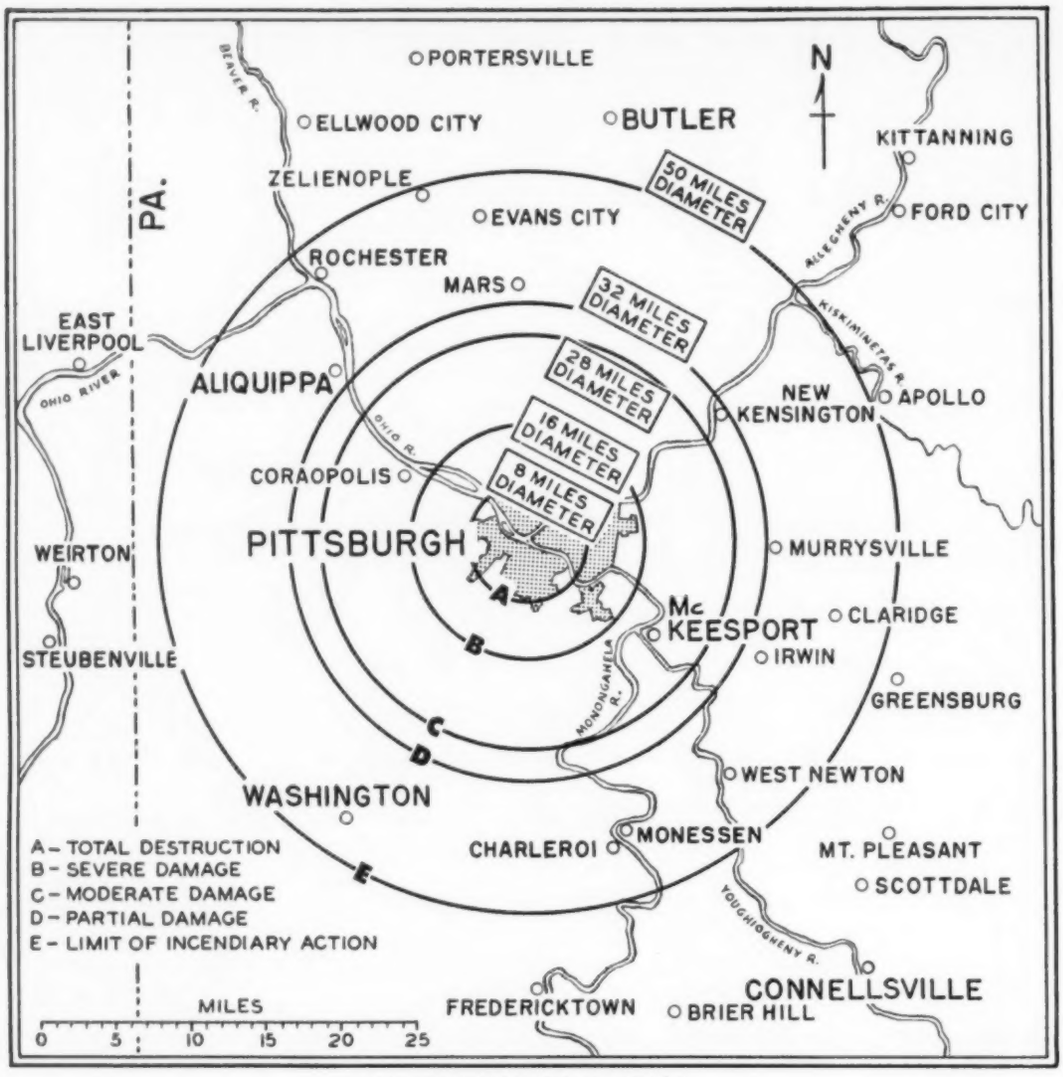


Figure 1 — Chart gives range of destruction from H-bomb in the Pittsburgh area.

the second part will relate the industrial phases as a counterpart.

Civil defense aspects of planning — The reader should now consider himself a newly appointed civil defense director in a city the size of Pittsburgh. His first thoughts would probably be: "I have a job to do. What are my duties, what are the problems involved and who can I get to do the work?" This job in many respects will be different from the one he now holds because of the volunteer aspects of the people who would assist him.

Look at a map of Allegheny County (Figure 1) on which the area of destruction of an atom and a hydrogen bomb is indicated. Also look at Table I.

The important consideration in these figures is that in any case, even with an H-bomb attack, the city would not be completely destroyed. A large percentage of the citizens would be alive. The remaining plants, although many may be severely damaged, would be vitally needed for industrial production.

Effects of an atom bomb on a community — Inasmuch as there are no available statistics for results of a hydrogen bomb attack on a community, take a 2½ × bomb (2½ times the size of the one detonated on Hiroshima) and look at what problems are involved. The following information was obtained from the Federal Civil Defense Administration urban analysis and verified by the State Council of Civil Defense. A problem with a fixed set of circumstances will be posed.

Community problem — Medical (Estimated Figures)

Population of a city	1,000,000
Population within 2½ mile radius	300,000
Type bomb (A bomb)	2½ × or 50,000 tons
Type explosion	Air burst — 2500 ft

Conditions — Average conditions with no concentration such as might exist at 12 noon in downtown area.

Results	Per cent	Number
A. Fatalities	30 =	90,000
B. Ambulatory injuries	13 =	39,000
C. Walking injuries	5 =	15,000
D. Uninjured — Homeless	52 =	156,000
Immediate feeding problem (B.C.D.)	=	210,000
Number of 200-bed emergency hospitals needed	=	195
Number of nurses @ ratio of 1 to 5 hospitalized	=	7,800

Number of doctors @ two hospitals = 390
Note: South Side Hospital in Pittsburgh has 285 adult beds.

COMMUNITY PROBLEM — CARE CENTERS

Lodging for homeless	171,000
Food preparation — (235 teams of 18)	4,230
Clothing — 5 Per cent need immediate attention	8,550
Registration teams — 60 Teams of 15	900
Lodging teams — 300 Teams of 7	2,100
Welfare assistance 130/10,000	2,200

PLANT PROBLEM

Total roll force	10,000
Total working force — Maximum	4,000
Type bomb	2½ ×
Location of plant — 1.3 to 2 miles from ground zero	

Results	Per cent	Number
Fatalities	4	160
Ambulatory injuries	13	520
Walking — Injured	8	320

Requirements — These injured must be cared for within the plant area for a period of 24 to 48 hr — FCDA instructions.

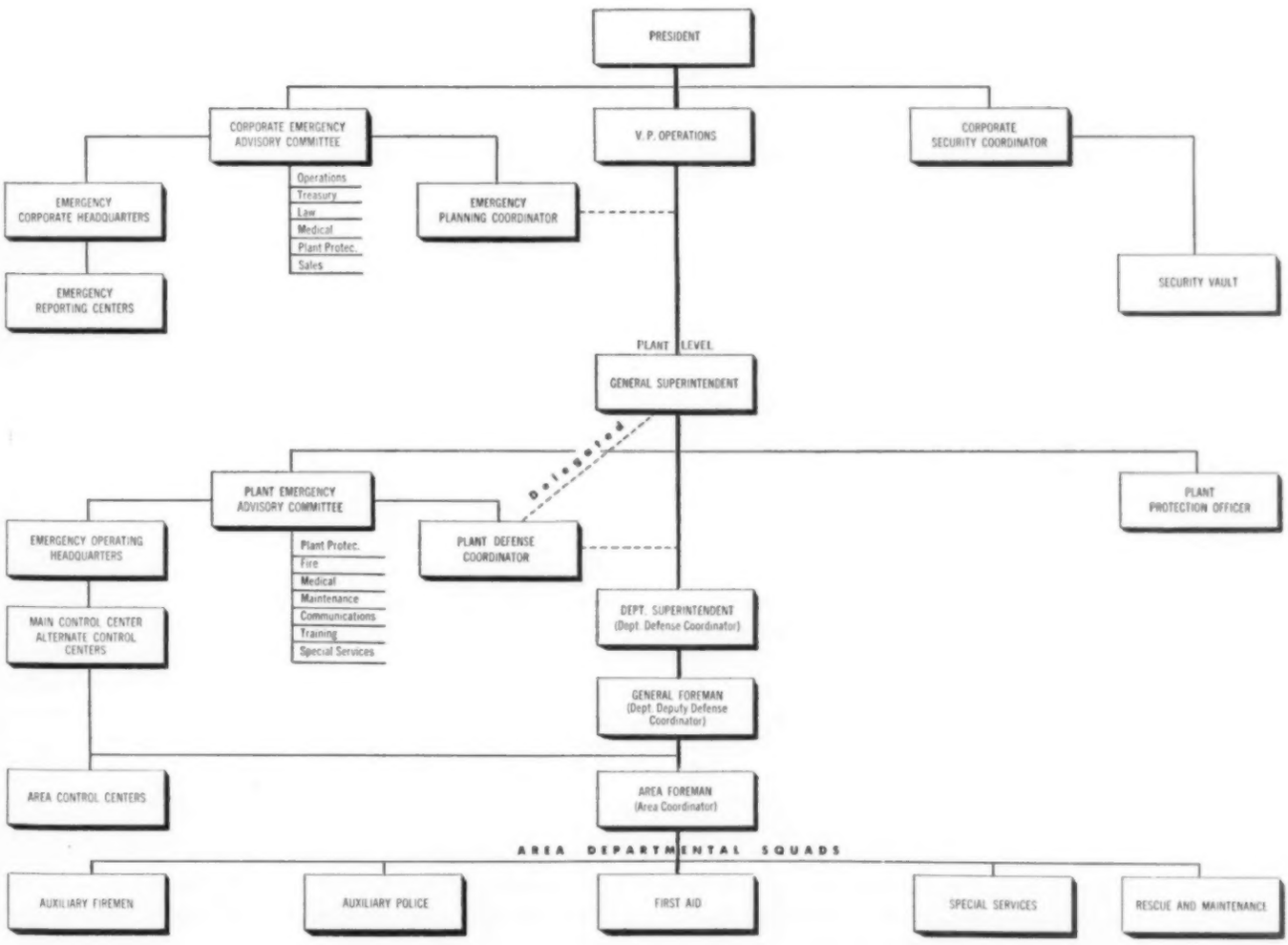
QUESTIONS FOR PLANT MANAGEMENT

1. Who would administer first aid to 21 per cent of the working force?
2. How would you obtain medical aid?
3. Where would 520 bed cases be hospitalized in the plant?
4. Where would water for drinking and medical purposes be obtained?
5. Who would cook the food and where would the food supply be obtained?
6. How would ambulance cases be transported to community emergency medical centers?
7. How and by whom would medical records be kept in a sequence?
8. Are there sufficient medical supplies?

These are some of the problems which the FCDA have stated are plant management problems.

This would only be a partial list because one also would need in his community auxiliary police, auxiliary firemen, communications, transportation crews, engi-

Figure 2 — Chart shows a recommended organizational chart for industrial defense.



neering help, health and sanitation experts and many other well trained people who can function properly and instantly.

PRE-ATTACK EVACUATION PLAN

About a year ago the Federal Civil Defense Administration, Governor Val Peterson, administrator, announced that a new order of protection of life from atomic attack should be considered. Mr. Peterson stated that, at the present time, we can rely on a 15-min warning period. The shelter system is the best means of protection if a bomb drops. However, the federal government is currently working on an early warning system, with radar rings around the United States, which should give from one to four hr notice of an impending raid. This early warning system should become effective sometime in 1957. At that time, Mr. Peterson states, it will be to the best interests of the citizens and the community to evacuate prior to the bombing — at least evacuate those who can be moved. This principle would alter the shelter concept considerably. Special shelters would be needed for a small segment of industrial workers, police and auxiliary police, and other members of organizations whose services would be required at their stations prior to an attack. Therefore by 1957, the majority of workers in a plant would be expected to evacuate from the area with other people in the community. However, a select group of important individuals would be required (by the management) to stay and protect the plant equipment. Planning for evacuation of cities is in the embryo stages now, but will be discussed a great deal in the future. There are many people who say it cannot be done, but if the civil defense authorities are only partially successful in a city, one can readily visualize the problems he will have. How fast can supervision shut down an open hearth or blast furnace? Who will stay? Who will perform certain tasks in shutting down? Where will those who stay find good shelter? At what point will they leave equipment to go to shelter? Most certainly supervisors should have shut down procedures in written form so that management can take a good look at them.

Now look at the high points of planning for industrial defense. The charts now used are summarized from the "Industrial Defense Planning Manual — Iron & Steel" which was printed in September by the American Iron and Steel Institute. This manual was developed by a task group for the department of commerce. Members included four from the largest steel producers and four from small companies. It was headed by W. P. Getty, assistant vice president production of Jones & Laughlin Steel Corp. and J. E. Lose, assistant executive vice president operations, U. S. Steel Corp. This task group worked in conjunction with the department of commerce, the ODM and other government agencies in Washington to set forth a cross section of requisites for proper pre-attack planning for a national emergency. At the outset each of the eight companies in the task group stated briefly those steps which had already been taken by their companies. These items were tabulated and, after a considerable amount of research in government pamphlets on defense subjects, as well as a review of outstanding manuals of various corporations, a manual was prepared. This manual was reviewed in great detail by task group members and by representatives of government agencies. It was finally issued on September 9, 1954 by the Iron and Steel Institute for the department of commerce.

Figure 2 shows a typical industrial defense organization chart, and Table II.

TABLE II

Industrial Defense Planning— Important Phases

Administrative
Continuity of management — predetermined replacement list
Safeguarding company records — security vault
Protection of current assets
Emergency corporate headquarters plan
Reporting centers
Financial aid to employes
Industrial cooperative assistance
Liaison with Federal, state and local civil defense
Power of civil defense director
Personnel
Emergency personnel records
Shelters
Feeding and housing disaster victims
Security
Security control of personnel
Protection of vital plant areas
Communications
Emergency equipment — 2-way radio
Emergency alerting — signal system
Messenger service
Information to employes
Training
First aid
Fire
Rescue
Auxiliary police
Refresher
Medical
Emergency supplies
Casualty stations
Identification
Rehabilitation
Spares inventory
Emergency transportation
Maps of plant utilities
Secondary water supplies
Emergency light and power
Fire fighting facilities

SUMMARY

In quick review consider again the effects of an atomic explosion upon one's company. Its production facilities would be damaged and in need of immediate repair. Many executives and employees might be killed or temporarily incapacitated. Records might be destroyed and the assets lost, and finally the interests of the stockholders might be impaired or even destroyed.

The problem then is what can managers in industry do now to lighten the burden of such a possible disaster. It is suggested that the reader obtain a copy of the Industrial Defense Planning Manual and read it thoroughly. Study it, noting which suggestions fit his own situation and then think creatively in applying them.

DISCUSSION

PRESENTED BY

JOHN J. KNIGHT, Works Manager, Fairmont Coke Works, Sharon Steel Corp., Fairmont, W. Va.

W. R. RAMSAY, Industrial Defense Coordinator, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

T. M. FAIRCHILD, Assistant to General Manager, Bethlehem Steel Co., Johnstown, Pa.

P. R. HOLDEN, Guyan Machinery Co., Logan, W. Va.

THOMAS E. DIXON, Special Associate, Mellon-Stuart Industrial Construction Co., Pittsburgh, Pa.

C. W. SWANN, Safety Director, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

O. P. ROBINSON, District Manager, Cutler-Hammer, Inc., Pittsburgh, Pa.

M. D. AYERS, Chief Engineer, Wheeling Steel Corp., Wheeling, W. Va.

E. L. TINDALL, Chief Engineer — Manufacturing, United States Steel Corp., Pittsburgh, Pa.

ROBERT R. DIGBY, Superintendent, Eichleay Corp., Pittsburgh, Pa.

John J. Knight: To what extent would you expect sabotage, timed with a military attack, either from your own employees or professional Reds from outside, in the way of fires or in plant explosions? My reason for the question is the feeling that we could possibly be attacked by one or two large countries which are potential enemies. In such case there might be simultaneous all-out nationwide disruptive activity in our manufacturing plants.

W. R. Ramsay: Government officials tell us this would definitely be a very serious problem, and you should know who these people are. It is your responsibility to know who they are if at all possible. That is one reason you have plant security officers. Any information you have along that line — people whom you might suspect — should be reported to your security officers immediately and to the FBI. Sabotage would go hand in hand with an atomic attack, or any type of a war.

T. M. Fairchild: Does J&L have an emergency headquarters, and if so, where is it?

W. R. Ramsay: We are presently planning an emergency headquarters. Just exactly where it is I can not tell you. It will likely be an existing facility.

We do not have the $500,000 to spend for it as another company did. We believe, however, we can go to the emergency headquarters and set up business in a fairly reasonable time.

Our plan will go before our Industrial Defense Advisory Committee for review soon. It is about a 30-page manual.

P. R. Holden: I understand that nike installations are being put up around Pittsburgh and other cities. How would that affect the defense setup of Pittsburgh?

W. R. Ramsay: There will be 12 nikes. Two of them will be completed in Pittsburgh in March, I understand. Now the nike, a guided missile installation, is reported to be 90 per cent effective. In other words, of 100 planes, 90 of them would be knocked down. At the present time only about 30 of 100 planes would be destroyed. And the nike, as a guided missile instrument will destroy other guided missiles. Therefore our situation will soon be improved from where you now have only a 30 per cent chance of knocking them down, to a 90 per cent possibility which will be a very definite improvement.

Thomas E. Dixon: You have dwelled at some length of security of records. Is it the general practice now of most companies to microfilm all important records and keep them in their vaults?

W. R. Ramsay: We microfilm possibly 30 to 50 per cent of our records. A large number of records need only be secured for a definite period of time, such as three months, six months, nine months, etc. We do not microfilm those records. However, we send copies of these records to the security vault daily. We have employees working there regularly every day. Those records that need be kept 30 to 90 days — and those that are not needed indefinitely, are destroyed by burning them up. That is pretty important. Why waste money to microfilm if it is only a matter of days retention? You should use duplicate copies for that purpose.

C. W. Swann: What has J&L done in the way of first aid training?

W. R. Ramsay: We have probably done something different at J&L than most companies, most plants in the steel industry particularly. We have trained nearly all our employees in some phases of first aid, such as artificial respiration, control of bleeding, treatment for shock, bandaging, splinting. Most of our employees have had that training. We do not do it over night. It takes months.

We feel it helps our safety program. Our safety director believes first aid training is helping the entire safety program. Up to this point we are nearly completed with first aid on the first round, and we will need refreshers for a certain number of those people at least.

We have our own first aid manual, it is about a ten hr course, depending upon the number of people in the class. You can give first aid to six people in possibly seven hr. If 15 employees are in the class, it might take ten hr for the same course, because each person gets individual attention. We have trained 10 per cent of our employees in our own course in the city office.

O. P. Robinson: Has anything been done in the Pittsburgh area on the subject of inter-company assistance?

W. R. Ramsay: Unfortunately, no. Inter-company assistance between companies in the Kanawha Valley, W. Va., where there are powder companies, has been well planned, and I think it is something that should be done in this area. It will require an organization of people interested in the subject to do a good job in Pittsburgh. It is a phase that the federal government believes to be very important.

M. D. Ayers: Recently we have heard a lot about radioactive ash fallout from hydrogen bombs. Do we have any information in regard to determining how dangerous an area would be that was in the path of this fallout? Also, would this ash fallout get into our streams

and rivers and contaminate our rivers which are used as a source of water?

W. R. Ramsay: You will have a certain amount of fallout. How much they do not tell us. All we know is that from the experience of the A-bomb in Hiroshima or Nagasaki, about ten per cent of the people died from this fallout material. Ninety per cent of them died as a result of being under falling objects, flying glass and burns.

It depends somewhat on the weather. Fallout would be more severe in rainy weather. If it is a water detonation, you do have a greater problem of radioactive material. If it is a clear, dry day, your fallout disappears in the air for the most part.

I might point this out to you. At a discussion in one of our meetings recently, a film company representative stated that just after the H-bomb detonation in Russia, I do not know how many days or weeks, but shortly after that, this film plant had to shut down their process for a day or two because of the fallout from Russia. However, it did not affect any of the employees. It did affect that process, which is a very delicate operation. (*Note:* Since the date of this meeting, Dr. Richard Gerstell, state civil defense director in Pennsylvania has given some detailed information about fallout. If you are interested, write Dr. Gerstell in Harrisburg for information.)

E. L. Tindall: In J&L, Mr. Ramsay, you mentioned coordinating committees. Do you have any single advisory committee that keeps in touch with the civil defense authorities themselves, or in general, advise your top management?

W. R. Ramsay: I am the defense coordinator and responsibile largely for making contacts in the Pittsburgh area. When I visit the plants in other areas, I also contact the civil defense coordinators in those areas. However, it is the responsibility of each plant, the defense coordinator, or one of his assistants, to make contact in each particular area.

For example, at Aliquippa, our defense coordinator, the superintendent of maintenance, frequently contacts the civil defense deputy coordinator at Aliquippa. The superintendent of maintenance, incidentally, in the steel plants, is the defense coordinator in all three steel plants. In other plants the coordinator may be the superintendent or some other person who is appointed, depending upon the size of the unit.

Robert R. Digby: Supposing you had the six men per hr availability at your first aid station, and you had 150 wounded from a bomb. In how many hours do you figure you could take care of that many people and still prepare your plant for continued operation after the bomb had struck?

W. R. Ramsay: We have not calculated how many hours it would take to rehabilitate the employees. One employee may be seriously injured — that may be six months. Other employees may have broken arms which might take three months. Other employees would have scratches and cuts, a matter of first aid attention and they would be ready to go.

Now as to your equipment, depending on how close you are to ground zero, it may be a matter of hours or even months.

It is a matter of preparation, and getting your people organized, and you may have to call for help from neighboring plants, or your own plants.

Member: You said the power of the civil defense director is supreme. How far do the powers extend? Who would take care of McKeesport and Clairton, and do they have anything set up for those plants?

W. R. Ramsay: The civil defense administrator in Washington is head of the Federal Civil Defense Administration. Each state has its own director. In Pennsylvania we have a civil defense director in Harrisburg for example. Each county has a director, and each community has a director, in that line of progression. Now the administrator may be thoroughly familiar with the problems at the federal level, but you must depend on your local director primarily in an emergency period. It is therefore important that you know the problems of your local civil defense director, and that he be familiar with your problems. Each community has its own director reporting to the county director. The local director is appointed by the governor who depends largely upon the recommendation of the mayor or burgess and the county director. All counties should have directors. I do not know of any that does not except Allegheny County. The city of Pittsburgh has not had a director for 12 months now.

Member: Does the county have one too?

W. R. Ramsay: The director for Pittsburgh and Allegheny County would be the same person. I understand the mayor and county commissioners are considering candidates at present.

WANTED!

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

Kilovar, Kilowatt and Voltage Control in the steel industry

By L. G. LEVOY
Power Systems Engineer
General Electric Co.
Schenectady N. Y.

. . . . proper control of electrical power taken by the steel plant can result in appreciable economies in power costs . . . . actual plan will vary with relative load, generating capacity and percentage of load purchased from utilities . . . . power contract is another important factor . . . .

▲ KILOVARS and kilowatts cost money, whether purchased or generated. Kilovars affect size and efficiency of generating equipment and transmission losses. Kilowatts, or more properly kilowatt-hours, represent energy and influence the size of generating equipment and amount of fuel consumed. Voltage control is important in that the life, performance and efficiency of practically all utilization equipment, including motors, control, lighting, transformers, etc. are influenced by the voltage level supplied. Basically, then, the proper solution of these problems is the one which results in the best overall economics for plant operation.

Steel plants can be divided into the following three categories:

1. Plants which generate all of their own electrical power.
2. Plants which generate part of their electric power and purchase part from the utility.
3. Plants which purchase all of their electric power from the utility.

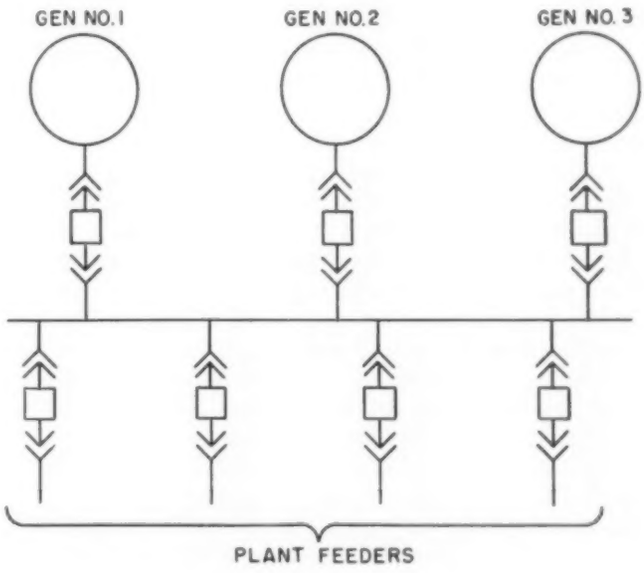
Problems of kilovar, kilowatt and voltage control arise in all of these plants but, since the problems are different, we will treat them separately.

PLANTS WHICH GENERATE ALL OF THEIR OWN POWER

Figure 1 represents a one-line diagram of a simple system which is isolated from the utility.

Fundamental requirements of parallel operation — In such a system, voltage regulators would normally be supplied for each generator. However, the division of load (kilowatts) among a-c generators operating in parallel is dependent upon the mechanical power supply to each generator, as controlled by the governor of its prime mover, and is practically independent of excitation. The division of reactive current (kilovars) among generators is a function of the excitation. For operation of the generators in parallel, the system of voltage

Figure 1 — One-line diagram shows isolated generating plant.



regulation should, therefore, provide for proper division of the reactive current among the machines.

In applying a system of regulation to a number of a-c generators operating in parallel, it should be remembered that the change in excitation of any one of the generators does not appreciably affect the bus voltage. The chief effect is to change the reactive current supplied by that particular machine, as the other machines will tend to maintain the voltage level constant. Increasing the excitation will tend to make a machine supply more reactive current, and decreasing the excitation will make it supply less reactive current. To raise the station bus voltage appreciably, it is necessary to increase the excitation on all of the machines, or at least on enough of the machines to have the desired effect.

Cross current compensation — To obtain successful parallel operation of two or more generators with individual voltage regulator control, the regulators must perform two main functions:

1. They must hold the voltage substantially constant.
2. They must provide proper division of reactive kva load among the generators.

To accomplish this the regulators must be provided with a means of changing the regulator set point as a function of the reactive current delivered by the machine. This scheme is known as "cross current compensation" as it tends to prevent the flow of cross currents between paralleled machines and to insure stable operation of regulated machines in parallel. Over the years many types of cross current compensation have been developed and used. Experience has shown that the system called individual compensation, in which the voltage sensitive element of each regulator is biased in proportion to the reactive current of the machine under its control, provides the simplest and most reliable system from the operating standpoint.

In this system the cross current compensation circuit varies the regulator signal voltage as a function of machine reactive current. As the machine overexcited reactive current increases the signal voltage applied to the voltage sensing element in the regulator is increased. Due to this higher signal voltage the regulator will act to reduce the machine excitation thereby reducing the overexcited reactive current contribution of this machine to the system. Likewise if the machine is operating under-excited, the cross current compensating circuit will decrease the signal voltage applied to the voltage sensing element so that the regulator will act to increase the excitation and decrease the under excited reactive current.

Reactance between generators — Figure 2 represents a case where there is reactance included between two generators or two power stations, each having its own regulator. This reactance may be in the form of transformers, reactors or transmission lines. In such a system, the voltage regulators can be operated successfully without cross current compensation, provided the reactance in the main circuit between the two regulated machines or stations is about 12 per cent, based on the rating of the smaller unit or station.

This figure of 12 per cent is chosen so that a minimum of attention on the part of the operator is required to maintain satisfactory division of reactive current by the machines. With lower values of reactance, the regulators can be operated without cross current compensation but the voltage adjuster of the regulators will require more frequent attention from the operators as the load pattern changes than would be required with higher values of reactance. For this reason it is recommended that cross current compensation circuits be provided for all voltage regulators regardless of whether or not there is reactance between generators. The amount of cross current compensation which is required for a given case can readily be determined by operating experience. In many cases no additional bias is required.

The effect of this reactance between machines or stations is similar to cross-current compensation, in that it gives a biasing effect with respect to the exchange of reactive current and, therefore, tends to cause the machines to divide reactive current properly.

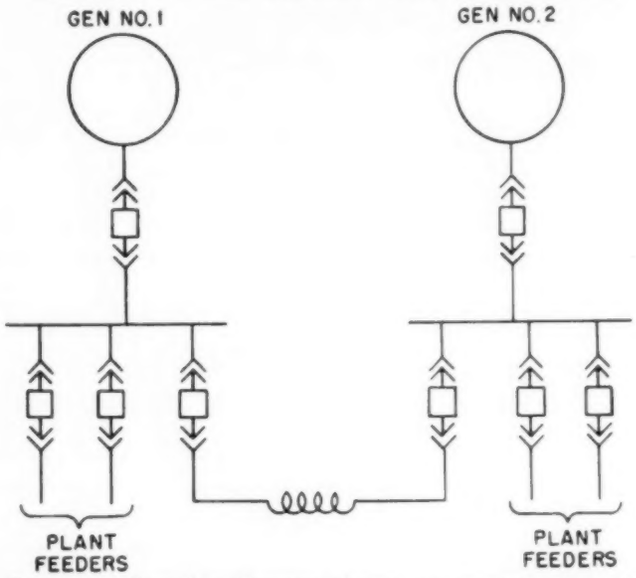


Figure 2 — One-line diagram shows a-c generators paralleled through reactance.

Line-drop compensation of voltage regulators — Generator voltage regulators are best suited to holding constant voltage at the generating station bus. It is possible to use line-drop compensating schemes to hold constant voltage at the remote end of a transmission line, however, this practice is not commonly used in industrial circuits. The line drop compensator can also be used to compensate for voltage drop at some electrical distance such as through a transformer.

Kilowatt control in the isolated plant — In the isolated plant, the kilowatt load on the generators is the total plant load and the prime mover governors are normally speed governors, so that as load comes on, the speed and frequency tends to drop so that the governors open the turbine control valves wider to permit the prime movers to deliver more power as required. Consequently, the kw of generation is automatically matched against the kw of load demanded by the system. No further control of kw is needed except possibly to so schedule plant operations that the machine capabilities are not exceeded.

PLANTS OPERATING IN PARALLEL WITH THE UTILITY

Plants which generate part of their electric power and purchase part of it from the utility are faced with certain additional problems, as follows:

1. Sharing kw and kva demand with the utility in such a way as to minimize billing charges.
2. Maintaining satisfactory voltage levels in the plant, irrespective of any normal variations in the utility voltage.

Control of kvar — Figure 3 represents a plant operating in parallel with the utility. In the figure, the utility tie transformer is shown with load ratio control. Consider first the case where the utility tie transformer is maintained at a fixed ratio. In this case, if the utility voltage is maintained substantially constant, kilovars can be shared within the limits of capability of the industrial plant generators by controlling their excitation. This will, of course, cause some variation in the voltage level of the plant bus. If this voltage level variation is not acceptable, or if the utility voltage is subject to an excessive range of voltage, then the connection to the utility should be made through a transformer having load ratio control. In this way, the flow of reactive kva can be controlled by changing the transformer ratio and at the same time maintain the plant bus voltage at the desired level by control of the generator excitation. Unless this precaution is taken, the industrial plant bus voltage will vary as the utility voltage varies, and if the local generators attempt to hold the plant bus voltage, there will be no control of the reactive kva interchange between the plant and utility systems. When this situation exists, load ratio control should always be used.

Where load ratio control is applied to the utility tie transformer for an industrial plant which is operating its generators in parallel with the utility, as indicated in Figure 3, the load ratio control can be adjusted manually as required, to maintain satisfactory control of vars if the utility voltage is relatively steady, and this manual control does not require excessive attention on the part of the operator. Direct control of kvar can be accomplished by using a var sensitive master element. Also LRC equipments usually contain standard automatic control devices, including a voltage regulating relay and a line drop compensator, so that they can be made to automatically control the reactive kva by merely reversing the reactive component of the line drop compensator and adjusting the spring tension on the voltage regulating relay. In this way, the kvar can be held at zero, or a particular value can be caused to flow in one direction or the other. The essential requirement is that the local power system maintain a constant voltage against which the voltage held by the LRC transformer can be balanced. In event of a loss of power from the local generator, the LRC can be left in its last position and put on manual control, or automatically be cut over to straight voltage regulator control as desired.

Kw load control and governing — In the system shown in Figure 3, the kw load on the plant generators is established by the turbine governor operating on the turbine control valves. However, in such a system, the utility frequency is normally held constant, so that the local plant generators cannot sense an increase in plant load by a small drop in frequency, as occurs in the case of the isolated plant. Consequently, a speed governor is ineffective in controlling the turbine output, unless its calibration is changed either manually or automatically as the generating requirements change. Thus, the local generator may be governed as a base load machine, or if operated non-condensing, its output may depend upon the process steam requirements.

It is obvious that the sum of the locally generated power, plus that power entering the plant over the utility connection, must always balance the power used in the plant. It is generally desirable to reduce the peak loads on the utility tie, since this is a benefit to the utility, and the customer may benefit by a reduced gross bill for his electricity because of the smaller demand charge.

Usually the amount of electrical energy consumed is proportional to the amount of production in the plant. However, the power demand which the customer imposes on the utility may have very little to do with the actual production. The most satisfactory and economical method of operating, as far as the power bill is concerned, is to fill in the valleys and cut off the peaks of the load curve by carefully scheduling production operations. By this means, the peak imposed on the utility equipment will be reduced and the customer's demand charge will be lower. However, it should be recognized that other factors and production requirements may overrule this economy of power.

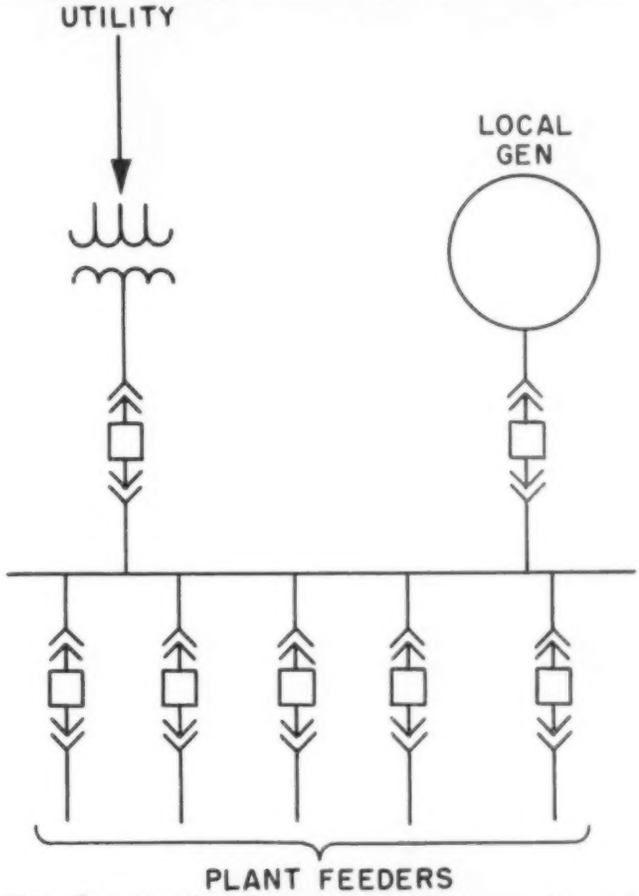


Figure 3 — One-line diagram shows plant operating with local generation in parallel with utility.

The demand is the maximum value of the average kw used in any interval of specified length during the billing period. The customer is naturally interested in carrying on his operations with the maximum efficiency and minimum expense. The highest efficiency is obtained by operating at the highest possible load factor which, in turn, results in the minimum gross charge for purchased power.

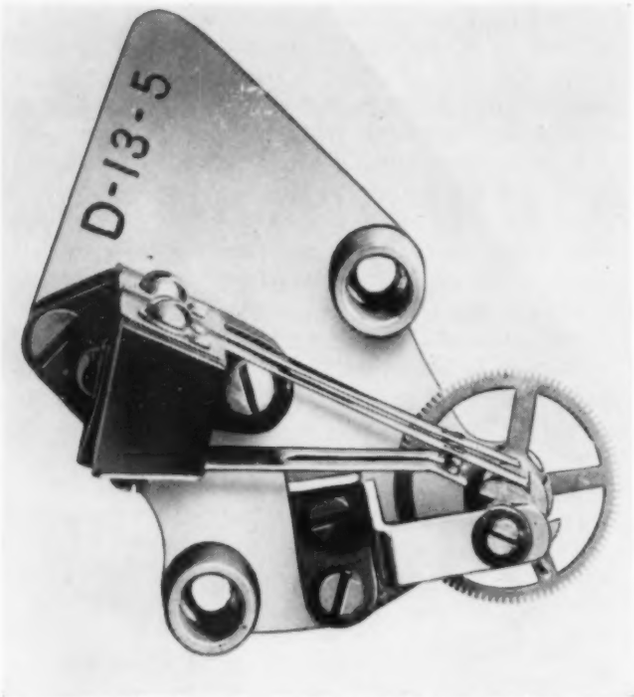


Figure 4 — Watthour meter contacts for use with demand meter.

The basis of the demand charge differs with different utilities and with types of customers. For example, some rates call for an established demand applying only to the month during which it is established. Other schedules apply an established demand not only to the month during which it is established, but also to the following eleven months. Still other rates are on the basis of "on and off peak" with a limited hour schedule during all or only a portion of the year.

The cutting off of the peaks and at the same time filling in the valleys, or in other words, load factor improvement, is the result of efficient supervision and a thorough knowledge of plant operation. Without any supervision, high peaks are established before anyone knows about them, and it is then too late — the peak has been established and the damage is done.

If the plant operating conditions are fully appreciated, certain loads need not be superimposed on each other, but can be staggered over the day. Unimportant loads, not vital at the moment, can be shut down for a short time during critical periods to relieve the situation, with the result that an accidental peak can be avoided. To assist in efficient operation of a plant, it is desirable to supplement its supervision with some system whereby an advance warning will be given than an abnormal demand is about to be established, at a point higher than that set as an arbitrary maximum. This may be strictly a warning calling for action of some one of the plant personnel, or it may take the form of automatically dropping non-essential loads, not vital at the time, long enough to relieve the situation. The restoration of the dropped load can be either manual or automatic.

Figure 4 shows a set of watthour meter contacts which can be installed in a watthour meter, Figure 5. These contacts can then be used to actuate a demand meter, Figure 6. The demand meter includes a set of contacts which make and seal at an adjustable position, corresponding to a given number of kwhr. These contacts automatically reset at the end of the demand interval. They can be used to ring an alarm or drop load.

Another refinement is to establish time bands in the demand interval by means of suitable timers so that if the contacts close early in the demand interval, a large block of non-essential load is dropped, and progressively less load is dropped if the contacts close later in the demand interval. This method is of particular value where several non-essential loads of differing priority can be segregated and dropped as required.

A still further refinement uses a demand meter with expanded functions, Figure 7. In this meter the actual use of power is compared with the ideal rate of use of power. The actual use pointer is advanced by impulses from the contacts in the watthour demand meter. A scale shows the kwhr used at any instant. A second pointer is advanced at a uniform rate which represents the ideal use rate. Contacts are provided so that the instant the actual kwhr exceeds the ideal use rate, a signal is established to ring an alarm or drop load. A further feature permits a larger rate of use in the early part of the demand period and decreases the rate permitted in the latter portion of the period. This is accomplished by offsetting the contacts so that a predetermined value of excess demand is allowed to occur during the beginning of the time interval. At the end of each demand interval, both pointers are automatically reset to their starting positions. One or more interruptible loads may be dropped sequentially by means of timers so that if the first reduction did not

Figure 5 — Polyphase watthour meter is used in conjunction with a demand meter.

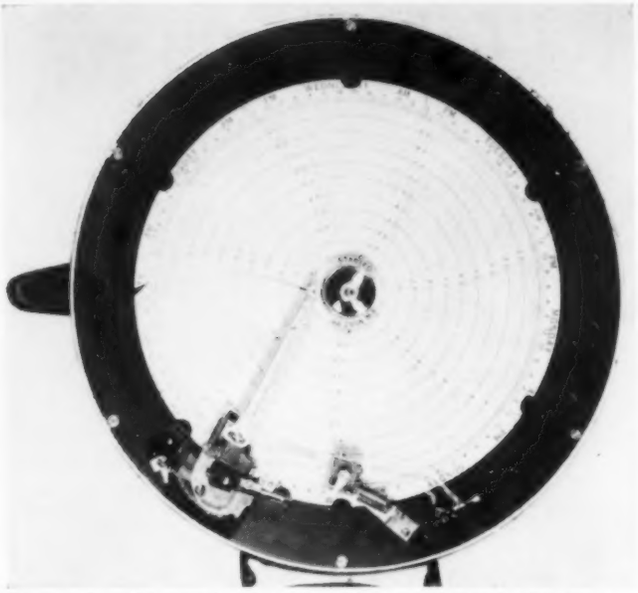


Figure 6 — Demand meter has limit contacts which make and seal at adjustable position, and reset at end of demand interval.

Figure 7 — Demand meter has adjustable limit contacts, actual and ideal rate-of-use pointers, time interval pointer, kilowatt-hour counter and dials.

decrease the use sufficiently, a second load can be dropped and so on. This is indicated schematically in Figure 8.

Load regulation by reserve generating capacity — In cases where it is not desirable to drop load to limit demand, such limitation can be accomplished by reserving some generation to supply added load when required. For moderate rates of change of load, this can be accomplished by a wattmetric signal amplified to operate directly on the conventional synchronizing motor of the turbine control. The normal speed of travel is about 30 sec for full range.

Turbines with quick-acting governors have been applied to plants where the rate of change of load was equal to full load in four sec. While it is possible to speed up the turbine governing mechanism, there is a limit to the rate at which the steam supply from the boilers can be increased without dropping pressure, so this factor must be considered where high rates of load change are involved.

Control of the peak and time interval demand made by an industrial on a utility system can often be justified by the net reduction in total power cost. A uniform demand on the utility system generally yields a minimum power rate. However, this results in an increase in cost of the local power which has to take all of the peaks and valleys, resulting in an increase in its power costs.

Sometimes it is necessary to minimize load swings on the utility system from the standpoint of effects on the system voltage, frequency, or tie-line loads. This is infrequently necessary, but has been occasioned by proportionately heavy demands for power made on the utility or where the utility tie is weak. Normally, the heaviest concentrations and largest variations in power occur in continuous hot-strip mills or in tandem cold-strip mills. In many such cases, it is possible to control steam turbines to absorb much of the peak loads, thereby taking much of the load swing off of the utility system. This is accomplished by sensing either the power to the load or the tie-line power and, by means of a quick-acting regulator, to proportion the turbine output to the load demand, thus relieving the utility tie from furnishing all of the peaks.

Very rough loads, such as heavy reversing blooming mills, are usually supplied from an induction motor motor-generator set with flywheel, with the peak load limited by a slip regulator so that the roughness of the load is reduced.

While it is always desirable from the utilities' point of view to have a smooth base load, the load need not be artificially smoothed out unless the disturbances are more than can be tolerated, and smoothing becomes a necessity.

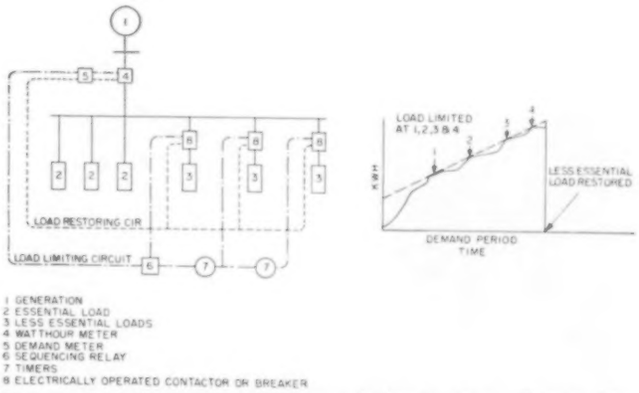


Figure 8 — Rate-of-use demand limitation. Excess demand over preset ideal use is limited as it occurs and in as many steps as desired.

The disadvantage of using a turbine generator set to smooth out a rough load is that if the generator is used as a regulator, the average load will be less than its rating, since capacity must be kept in reserve for the peaks. This may not result in the most economical operation and use of waste heat or fuel. In addition, the boilers and turbines will be subjected to rapid changes in steam and load demand, which will tend to shorten life and increase maintenance. The same is

true of the control valves, which will be kept more or less continuously in motion.

As an example of how a utility tie-line can be relieved of peak loads by special governing of the local generators, Figure 9 shows a typical wattmeter chart of a steel mill utility tie-line with and without the hot-strip mill in operation. In this case, the mill power plant contained three 20,000-kw turbine generators and was

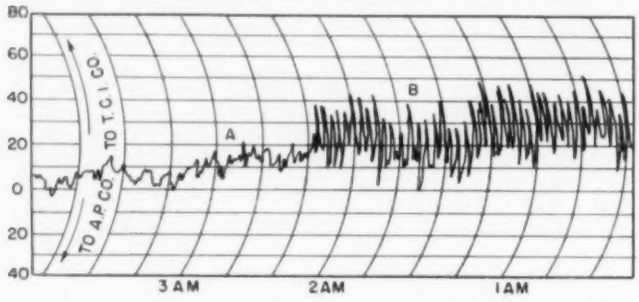


Figure 9 — Wattmeter chart of steel mill utility tie-line shows at (A) hot strip mill shut down, and at (B) hot strip mill in operation.

tied in with the utility. Note that the tie-line load is relatively smooth when the hot-strip mill is shut down, but fluctuates over a wide band when the hot-strip mill is running.

In this case, the utility found excessive interchange of power on some of their tie-lines, and requested the steel plant to minimize the swings. This was accomplished by providing quick-acting load regulators, which sensed the load on the hot-strip mill by means of a

Figure 10 — Front view of high response load regulator shows front doors open.

static watt-measuring circuit, the output of which excited a rotating regulator generator. The rotating regulator in turn operates the pilot motor of a hydraulic (oil) relay at the turbine to control the steam admission valves.

Figure 10 shows a typical load regulator control panel. Figure 11 shows the response of one of the regulated generators to the load, each generator picking up a fraction of the added load.

This resulted in minimizing the utility tie-line disturbances to a low level, which was not objectionable.

PLANTS WHICH PURCHASE ALL ELECTRIC POWER

Even though all power is being purchased, the plant can exercise considerable control over voltage, kilowatts and kilovars furnished by the utility.

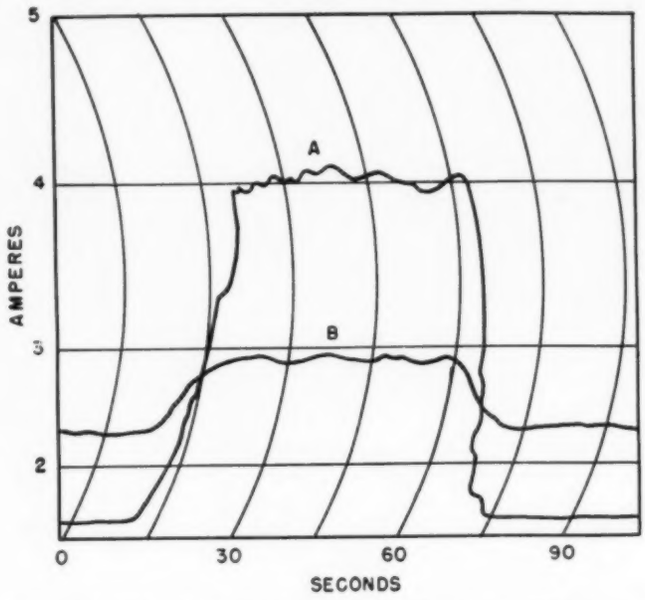


Figure 11 — Inphase current of regulated generator and hot strip mill for (A) hot strip mill, and (B) regulated generator.

Voltage control — Some of the ways in which the plant voltage can be controlled are as follows:

1. Load ratio control on utility tie transformer.
2. Fixed taps on utility tie transformer.
3. Fixed taps on intermediate voltage transformers in plant.
4. Use of power factor regulators on synchronous motor loads.
5. Switching of shunt capacitors.
6. Use of feeder voltage regulators.

The choice of the method selected naturally depends upon the circumstances of the particular case. If the utility voltage varies widely, load ratio control is usually the preferred solution. If the utility voltage is relatively constant but at a level which results in unsatisfactory levels of voltage in the plant, this condition can usually be corrected by fixed taps. If variation in plant loading is causing excessive voltage variation, this can frequently be corrected by use of power factor regulators on synchronous machines if such machines represent a large proportion of the total load, by load ratio control, or by switching of static capacitors. Feeder voltage regulators can be applied on certain critical feeders where it is desired to maintain specially regulated voltage.

While voltage control problems have been separated for purposes of discussion, it will be evident that they are frequently associated with other problems such as control of kvar, and the proper solution considers all aspects of the problem.

Kvar control — The plant which purchases all of its electric power is interested in kvar control primarily from the standpoint of power billing. It is important, therefore, to keep the plant power factor high enough to avoid penalties for low power factor or kvar demand.

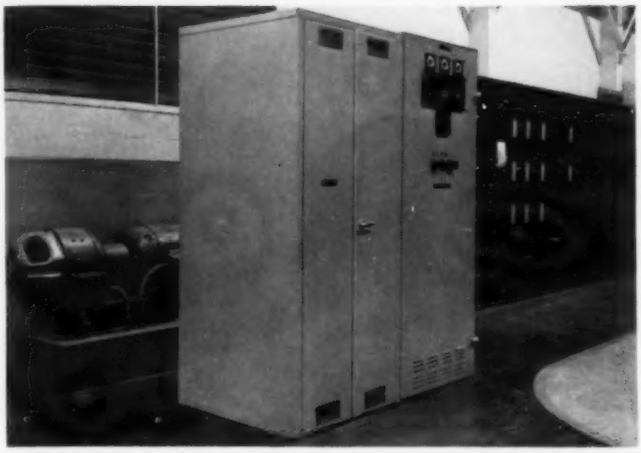


Figure 12 — Power factor regulator and field cubicle for 13,000-hp main motor-generator set drive motor for tandem cold strip mill.

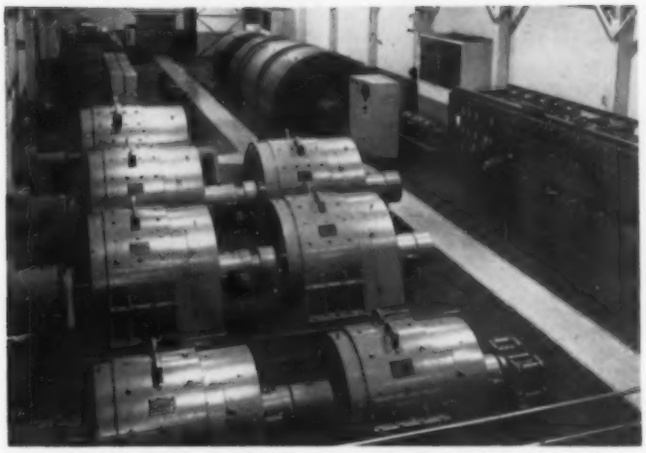


Figure 13 — View of motor room shows main motor-generator set with its power factor regulator and field cubicle, main drive motors and control.

Some of the ways in which this can be accomplished are:

1. Use of 0.8 leading pf synchronous motors to correct for other lagging loads. When necessary, power factor regulators can be used to control the fields on these motors. Figure 12 shows a typical power factor regulator and field cubicle; and Figure 13 shows its installation to control the power factor of a large motor-generator set.
2. Use of switched shunt capacitors or synchronous condensers.

Normally power factor regulators used with synchronous motors are adjusted to hold either the motor power factor constant or to hold the motor vars constant as the load on the motor changes. This insures adequate field on the motor at all times to provide necessary pull out torque. If the power factor controlled synchronous motors represent a large proportion of the plant load, the use of power factor regulators on them may be effective in maintaining the plant power factor. However, if the synchronous motor load is small compared with the rest of the plant load, it may be necessary to use additional corrective means in the form of static capacitors or synchronous condensers. Power factor control is usually put on large synchronous motors which are subject to wide variations in load to reduce both the voltage and kvar variation which would otherwise be present on the system.

Switched shunt capacitors are normally used in preference to synchronous condensers because the installed cost per kva is less. However there are certain uses where synchronous condensers are preferable because of the following characteristics which they possess.

1. A synchronous condenser can provide both leading and lagging kva and this is sometimes required for voltage control at a particular point in a system.
2. On a sudden voltage dip, the synchronous condenser contributes more vars to the system, thereby helping to support the system voltage and improving system stability. This is in contrast with shunt capacitors which provide less vars to the system when a sudden voltage dip occurs.
3. The synchronous condenser is capable of infinitely fine stepless control as contrasted with the fixed steps of switched shunt capacitors.

These characteristics of synchronous condensers provide a field for their application. In the steel industry, one common application is the use of a synchronous condenser and buffer reactor to supply arc furnace loads, thereby relieving much of the swinging kvar load from the system.

Kw load control — The plant which purchases all of its electric power is interested in kw load control to minimize the power billing charge. The only control available is to schedule loads to avoid coincident peak demands, which would increase billing unnecessarily as has been previously explained.

SUMMARY

This article covers the fundamental considerations of kilovar, kilowatt and voltage control, without going into the circuit details, since the overall picture is of more interest to most of this group. The equipment and circuitry for all of these control systems are available as standard equipment, and detailed explanations of their operation are available in published literature.

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DISCUSSION

PRESENTED BY

R. G. ORTHWEIN, Chief Electrical Engineer, A. J. Boynton and Company, Chicago, Ill.

L. G. LEVOY, Power Systems Engineer, General Electric Co., Schenectady, N. Y.

R. G. Orthwein: This excellent paper is of great interest to all steel works power plant operators, and ties in, to a certain extent, with an earlier paper which

I presented at the Spring Conference in Philadelphia dealing with the power system of Lone Star Steel Co. Proceedings AISE, 1954, p 918. Mr. Levoy took part in the discussions of that paper. At that time sufficient information was not at hand about the operation of load regulators, since not all phases of the power system had been completed.

It seems expedient at this time to supplement Mr. Levoy's remarks by some actual experience figures which we have observed at the Lone Star Steel Co. This plant falls into classification No. 2 of Mr. Levoy's paper; that is, the plant generators operate in parallel with the utility company.

Major swinging loads are produced by the operation of a slabbing mill, reversing hot strip mill, and two large resistance welders. The slabbing mill motor-generator set is powered by a 7000-hp wound rotor motor and the load swings are limited to 6500-kw by a slip regulator. The strip mill motor-generator set is powered by an 8500-hp synchronous motor equipped with an automatic field regulator to limit vars.

The welders are supplied by single phase alternators driven by synchronous motors, one rated 4500 hp and the other 2000 hp, 0.8 power factor and equipped with tapped field resistors.

Power is supplied to the steel plant via four 13.8 kv feeders. A 15 mw turbo-generator is connected to the power plant bus and the utility interconnection is made through two 10/12.5/16.7 mva transformers to 69 kv.

The utility company generating station, with a 40 mw turbo-generator, is located at the plant site approximately one mile from the steel company power plant. Further connections to the utility system are made at this station at 69 kv. The nearest generating station in the utility system is approximately 35 miles distant.

Because of the location of this plant in a remote corner of the utility network, the utility company was much concerned that the swinging loads of the steel plant would subject the utility system to voltage variations which might produce lamp flicker.

In view of this condition both the utility company's 40 mw and the steel company's 15 mw machines were equipped with automatic load regulators and rotating voltage regulators. Each regulator is self-contained and operates independently of the other. The regulator of the 15 mw machine is made sensitive to load changes by totalizing current in the four 13.8-kv steel plant feeders. The regulator of the 40-mw machine is made sensitive to load changes in the 69-kv current in the tie-line with the steel company.

The load regulator of the 15-mw steel plant generator permits operation of this machine as a base loaded unit, dividing load swings above base in any desired proportion between this machine and the utility, or may also take all the load swings if desired.

An incoming line kilowatt hour meter on the tie-line is equipped with contacts which actuate both a kilowatt printometer and a demand limiting meter. In the event that actual tie-line demand exceeds the ideal demand, contacts on the demand limit meter close, energizing the base load adjustor motor through a timer and driving it in a direction to increase load on the generator. If the load then drops off, excess power will be fed out over the tie-line and the operator must reduce base load setting on the machine manually.

At this point I would like to ask Mr. Levoy if this set-up could be improved to work both ways and thereby eliminate the need of manually resetting the base load.

At the time of start-up of the steel plant, the utility company generating station was not completed and the only utility tie-line consisted of a very small 69-kv circuit to a sub-station about 15 miles distant. During this interim period the load regulator was set to cause the 15-mw generator to take 100 per cent of the mill load swings and the turbine load limit stops were set at 17.5 mw.

The 8500-hp strip mill motor requires a starting load of about 2 mw, while the 7000-hp slab mill motor with its 195,000 hp per sec flywheel requires about 6.5 mw. It was observed that the initial swing hit the utility tie-line because of the relative capacity of the two systems, but the load regulator acted immediately to load the 15-mw machine.

It was estimated that less than one sec was required to bring the tie-line load back to zero.

A voltage drop of about 1.5 per cent was observed during start-up of the strip mill set and a drop of about 4 per cent during start-up of the slab mill set. Starting of other large motors was accomplished with equal ease.

Under these initial conditions, instantaneous demands of 6 to 8 mw were placed on the tie-line, but integrated 15-min demands were successfully held to zero, and only a small amount of energy was interchanged unintentionally.

Since the utility company's 40-mw generator has been in operation, the steel plant load regulator on the 15-mw machine has been set to take 30 per cent of the swings with the remaining 70 per cent of the swings going to the utility. It is the utility company's practice now to set the load regulator on the 40-mw machine at 50 per cent of its share of the swings and let the remaining swings be absorbed by the system. In initial testing they have set the regulator at 100 per cent and have kept all swings originating from the steel plant from their system.

On the basis of our experience at Lone Star Steel Co., we feel the load regulator installation is very successful in relieving the utility system from excessive load swings and in limiting 15-min demand on the utility.

Furthermore it may be well to point out that it has not been necessary to schedule operations in such a manner as to reduce possible load peaks and in no case are loads dropped.

The operating personnel greatly appreciates the regulator, purely on the basis of performance, and would not be without it.

Member: I just want to take a few minutes here to discuss regulators as they apply to the different types of furnace installations. Now many of you have arc furnaces and they share, or form a fairly large part of your load. One nice thing about them is the fact that they are easily dropped off. That is, if you are operating at, say, 20 megs you can easily change down to 18 in case you start taking over the demand at any particular period. For this reason they have been used in the past, a great deal, to keep the kilowatt demand of the entire plant at the pre-set level desired and as determined by the company — and the power company.

We have an installation on an 80,000-kva furnace plant. These furnaces are submerged arc type and they run at very, very high load factors — at about 95 per cent power factor. For this reason the demand is very high and if they ever go over the demand they pay very, very highly for it. For this reason they do all they can to maintain their load at this desirable level.

On that installation we use motor driven regulators. That is, instead of having standard manually or automatically operated furnace electrical controls we have special motor driven controls operated by the company plant loadmeter. This has proven to be quite satisfactory and is doing good service there, keeping their load at 100 per cent demand.

Another installation — on two 18,000-kva furnaces, there is a different type of regulator. Here we use a meter such as Mr. Levoy discussed wherein there are two motors, one actual and one pre-set. That is, one pointer moves forward at a given rate determined by the power company and the other pointer moves forward at a rate determined by the consumption of power. If the actual pointer overtakes the ideal pointer a relay changes the resistance in the arc furnace circuits so that the furnace is always operated at the same or rather, it operates at different power levels determined by this control and not determined by the furnace operators.

There is another type used on very small installations, and it is inexpensive. It consists of a meter with four different points or, rather, four different contacts. These contacts are set for different levels of demand; such as 97, 98, 99, 100 per cent demand. Any time during the fifteen or thirty min intervals, if we ever get up to that demand, these contacts cause changes in the arc furnace circuit — resistance in the current circuit of the arc furnace and thus we regulate our load again according to the plant demand, and in a very simple manner.

This is, admittedly, a rather specialized subject but I thought I should bring it forward at this time because so many plants do have these arc furnaces. Many of you will find that they can be used to regulate the entire plant load.

L. G. Levoy: To answer Mr. Orthwein's question, it is perfectly feasible to automatically recalibrate the base load control both up and down so that the operator would not have to touch the control in event load drops off causing reverse power to flow in the tie-line momentarily. This second recalibration circuit requires additional equipment and it is purely a matter of economics whether or not it is justified. Ordinarily a reverse power alarm is used to signal the operator, as this is less expensive than automatic recalibration. Fast action for reverse power is not as essential as for excess forward power since reverse power does not affect the billing. However, some saving in fuel costs can be realized by minimizing reverse power flow and at the present time we are building a load controller which automatically recalibrates the base load either up or down as required.

In connection with the discussion on use of arc furnaces to regulate plant demand, this is perfectly feasible and we have furnished controls which operate on the arc furnace regulators instead of the local turbine generators for demand limitation. Of course, as you all realize, cutting back the arc furnaces to reduce plant load for demand limitation purposes cuts down on the arc furnace production. This again, is purely an economic problem. You have to decide whether the possible saving in electric power billing is greater or less than the production loss involved. This is a matter for each individual plant to decide.

PERMEABILITY OF SINTER-PLANT FEED*

▲ THE primary operation in the sintering process is the forcing of an air stream through a more or less porous bed of fine material for the purpose of burning the fuel contained and thereby obtaining sufficient heat to agglomerate the particles in the bed. It must be recognized that there are many associated problems, such as proper ignition, cooling of the bed, and others, but they are essentially secondary. The real problem, then, is to obtain on the machine a bed that has the maximum possible permeability, and which, incidentally, has the proper amount of fuel. This permits the most rapid air flow with the fastest burning, which is essential to a high production rate.

Considering that the permeability of the feed to a sintering strand is of vital importance in the sintering process, this study has shown by the laboratory investigation of three basic sinter feed mixtures how the permeability of the raw feed is influenced by the amount of return fines and the moisture content. The results indicate that the method of mixing has an important effect on feed permeability. A rolling type of mixing appears superior to the conventional pugging action. Data are also presented to show quantitatively that the basic ore or ore-flue-dust mixture has an important bearing on the permeability of raw sinter feed.

Calculations are presented to show that with three given basic mixtures, a variation in the amount of returned fines will not influence appreciably the productivity of the machine as long as the operator is able to control the moisture level and thus sustain feed conditions at the "point of maximum permeability."

The investigation leads to the conclusion that the following conditions must be met to provide the sinter-machine operator with the needed control of his feed materials for maximum productivity:

1. Weights and proportions of raw materials in the feed must be accurately controlled.
2. Moisture content of the feed must be under the operator's control (± 0.75 pct seems necessary).
3. Control is required over the flow and physical character of return fines.
4. Proper mixing is needed to provide a "pelletized" feed.

It is also considered desirable that the operator have available a permeability chart showing the influence of moisture and return fines on the permeability of each of his basic feed mixtures. These would be of help to him in establishing the conditions for optimum operations with any given feed mixture.

*From paper by M. O. Holowaty and John F. Elliott, Chief, Raw Materials Section, Research and Development Dept., and Assistant Supt., Quality Control Dept., Inland Steel Co., East Chicago, Ind., presented at Blast Furnace and Raw Materials Conference, Philadelphia, Pa., April 18, 1955.

What Type of Grease for that application?

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Vice President
and
W. C. BRYANT
Research Director
Magie Brothers Oil Co.
Chicago, Ill.

. . . . tests conducted in the program reported indicate that for steel plant use, a minimum of four distinct types of grease are needed to obtain top performance . . . . some of these may have to be purchased in two or more grades because one grade will not serve all seasons . . . .

▲ THE title of this paper may sound like the title of some mystery story but we have to admit right here that it is only an investigation of our mutual interests. We have attempted to apply our grease manufacturing experience to the many and varied lubrication problems encountered in steel mill operation. The author recognizes good performance first with the maintenance department's desire for as few greases as possible and the operating personnel's concern over the cost of lubrication per ton of steel produced. With dusty atmosphere prevailing in most steel mills, greases are most practical and oftentimes superior to oils because of their ability to seal bearing ends. Difficult to reach and often neglected bearings require less frequent attention when lubricated with grease because the solid lubricant is retained for longer periods. Worn bearings, damaged surfaces and intermittent operations can best be lubricated by grease.

This paper does not recommend any all purpose grease —we wish we could do so because it would greatly simplify our manufacturing and inventory problems — the duplication of many greases in each of the various sized containers is costly and unproductive. There are certain basic reasons why we cannot conscientiously say one grease will handle all applications. First, we do not believe it is good lubricating procedure to use an all purpose grease just for simplification when this lubricant may lack certain important characteristics for a particular job. Second, why use a high price grease with high melting point characteristics where there is no heat condition and where the grease is generally fed in large quantities, such as on strip mill bearings, to keep out water and abrasive ironoxide. Cost is a factor here unless it can be definitely proven a higher priced, higher melting point grease which may remain in the bearing longer, will at the same time seal the operation from outside interference. Furthermore it is pretty well agreed that a grease, being a complex gel structure that derives definite lubricating qualities from its basic oil, is not much better than its oil — this means that in spite of the melting point of the grease, temperatures much in excess of 200 F are not practical with petroleum oils unless severely inhibited. Greases are made with petroleum oils for field service conditions ranging in excess of 200 F, but we find that all such compositions are limited in some degree or other when the higher temperatures are encountered. Past experience indicates that these undesirable developments might be noted in excess oil bleed, thickening or thinning of the grease structure, formation of carbon or development of rancidity.

Again, what grease for that application — we do not favor any particular kind of grease such as calcium, sodium, lithium, bentone, barium or combinations of these, but we want to investigate which will do the best job for each operation and for the greatest number of applications. Our approach to this problem is to bring together certain laboratory tests that we believe can reasonably be used to indicate the field performance that might be expected from the lubricants tested. With these tests at hand and in light of our own field experience, we will then look to most of the major steel mill operations to see what type of grease for that application, and to see if calcium-sodium-lithium-bentone or barium is the best recommendation from the standpoint of performance, simplification and cost. All greases tested in this study have the same viscosity mineral oil

TABLE I

	Drop point	Gel strength		
		77 F	150 F	200 F
Calcium	202	275	315	....
Calcium modified	200	275	301	....
Calcium modified EP	195	278	299	....
Lithium	337	275	299	317
Lithium modified	350	275	295	305
Lithium modified EP	326	281	294	303
Sodium	312	281	352	315
Sodium modified	310	280	305	296
Bentone	None	277	296	311
Barium	371	278	289	296

of 75 @ 210 F with approximately 70 viscosity index. Greases are No. 1 NLGI grades. Test data is reported on the calcium, lithium and sodium greases in both a good commercial grade as well as on an improved type developed for steel mill application.

For some time we have felt that the ASTM drop or melting point test did not properly indicate field performance. In Table I we are showing the plasticity or gel strength of the different types of greases at elevated temperatures in terms of the 58-gram cone penetration. Compare these against the drop point and you can see drop alone is misleading. Up through the 150 F temperature range, the conventional soda grease weakens in gel strength more than any of the low melting point calcium greases, but reverses itself before 200 F going from a smooth to a fibrous structure. We noted that when either of the sodium, bentone or barium test greases were held for 16 hr at 250 F, they became ropey and bled. The lithium greases changed much less in structure but showed some bleed. The calcium greases, of course, could not be tested at these elevated temperatures.

TABLE II

Norma-Hoffman Oxidation (Hours at 10 psi Pressure Drop)

	Not inhibited	Inhibited
Calcium	16	100
Calcium modified	26	100
Calcium modified EP	100	
Lithium	12	100
Lithium modified	16	100
Lithium modified EP	100	
Sodium	12	100
Sodium modified	12	100
Bentone	6	27
Barium	21	100

(Where 100 is shown above in all cases these are 100 hours plus)

The Norma-Hoffman test indicates the resistance of a grease to breakdown from oxidation both in operation and in storage giving us the best information next to lengthy field work on what to expect from each lubricant. Storing of grease drums adjacent to steam lines within the central oil house has been known to promote the deterioration of the contents so they could not be used. In Table II our results are expressed in terms of hours for ten lb drop in pressure. All the experimental greases were tested with and without oxidation inhibitors. On the inhibited lubricants the same amount and type of chemical was used in each case. The results show how greases may be protected against deterioration. Note the desirable effects certain types of extreme pressure additives have on retarding oxidation without the use of an inhibitor. Our findings indicate the bentone type requires more additive than the others. Barium appears the best without any inhibitor probably due to the effect of a higher soap content.

AN-G-5A tells us what to expect from the severe and constant action of water in the bearing assembly. A 204 ball bearing is rotated at 600 rpm for one hour with a jet of water impinged against the seal opening at a rate of 300 ml per min. In Table III results should be read in percentage of actual grease loss. We believe a 50 per cent maximum wash out is accepted as a passable

TABLE III

	Water tests	
	(Per cent grease loss) AN-G-5A	(Per cent water taken in) Chrysler
Calcium	21.8	15 O.K.
Calcium modified	12.4	11 O.K.
Calcium modified EP	17.9	18 O.K.
Lithium	41.0	50 O.K.
Lithium modified	33.8	18 O.K.
Lithium modified EP	38.9	60 O.K.
Sodium	84.2	20 N.G.
Sodium modified	48.7	100 O.K.
Bentone	29.5	20 O.K.
Barium	26.4	18 O.K.

grease subject to inspection of bearing after test. In our examination of the bearings, we found that in the case of the sodium greases only, there were dry unlubricated sections, but this is to be expected where there is constant water washing since the sodium grease is not intended for use under these conditions.

Also in Table III, 461-C-14 Chrysler test method gives us the information we need to know on how much casual or occasional water a grease will absorb without change in consistency. The Chrysler method is a simple churning technique from which we can determine the amount of water a grease will accept until there is a definite change in structure or before free water shows. Results are read in percentages of water taken in and the condition of the lubricant. If the grease accepts some water and then throws the excess quantities off with no appreciable change in body such a grease would be generally ideal where there is no constant washing action. According to our findings if there is only casual water the modified sodium was satisfactory.

From the above tests we are guided in our selection of a grease for large heavy duty roller bearings used in the modern strip mill. Failure on the part of the grease to throw off excess water generally results in the formation of so-called mayonnaise type emulsions with a decided loss of grease body and eventual loss of grease from the bearing proper. Where adequate control of water acceptance is imparted to the grease we have noted that free water is discharged to the bearing relief and subsequently from the bearing proper.

In Table IV, the Shell roll test seems to give a very good indication as to what we may expect from constant agitation and pressure in the bearing — if a grease either increases or decreases in consistency obviously the grease has an unstable gel structure and is not desirable. The figures shown indicate the percentage breakdown of the grease after four hours in the machine. All the greases except the calcium softened from a No. 1 grade to No. 0 but neither the lithium modified nor barium changed enough to become unacceptable.

Also in Table IV we show the results of our tests on the ability of a grease to protect a bearing against dust or dirt. We use a No. 204 single shielded ball bearing rotated at 800 rpm in an air chamber contaminated with 30/60 mesh oven dried Fullers earth, kept in constant circulation by both a fan and impeller. Results are reported in hours before the dust caused the bearing to lock. From our test data we observe that greases made with heavy oils give much better dirt sealing power

TABLE IV

	(Per cent breakdown) Shell roll	(Hours to locking) Dirt seal
Calcium	0.7	4.3
Calcium modified	1.1	5.1
Calcium modified EP	1.4	5.6
Calcium (135 @ 210 oil)	....	24.7
Lithium	17.2	2.7
Lithium modified	8.8	5.1
Lithium modified EP	9.1	4.4
Sodium	29.5	6.7
Sodium modified	21.6	7.6
Bentone	8.4	6.1
Bentone (110 @ 210 oil)	....	7.7
Barium	6.0	5.1

and that the type of soap or gelator used makes little or no difference.

In Table V we show our test results on what to expect of each type of grease on separation under pressure in the centralized system. The method is our modification of a test procedure which is being experimented with by others. We place a 20-gram sample on a stainless steel sintered filter disc of 10 microns porosity applying 28 in. of vacuum for 5 hr. Our work indicates this has the effect of pressure in excess of 100 psi. The results are reported in percentage of oil separated from the grease.

The steel industry has led the way in the use of the highly efficient centralized lubrication systems. In these, we must employ only those types of grease that have demonstrated little separation or change under constant pressure. The test data here reported seems to confirm information we have received in the field.

Also in Table V we show our results on oil bleed in accordance with the AN-G-3A test at both 150 and 212 F. Results are reported in percentage of oil released. The AN-G-3A bleed test requirements indicate that some bleed is not to be construed as detrimental up to a certain maximum, in fact, it is even to be desired. We feel that there must be some bleeding but in small amounts so that the separated oil under actual operation will contribute to the lubrication as long as it does not evaporate or run out. However, excessive bleed leaves heavy soap or gelator which may plug the system or the bearings.

In Table VI, there are pumpability results taken from the same centralized system pump which forces the grease under examination through 8 ft of $\frac{1}{8}$-in. copper tubing with bends to approximate 190 ft of straight line in a centralized lubrication system. This tubing is led through a cold box in which we can vary the temperature from 70 to minus 20 F and measure the discharge pressure at the pump along with rate of delivery at the end of the tubing. For simplification we show only the discharge pressure readings and selected 10 F temperature at the suggestion of several steel mill lubrication engineers. Our test data has convinced us that the viscosity of the oil and not the type of soap determines the pumpability characteristics. The exception in this case of bentone we think is due to its inherent characteristics of resistance to shear and temperature changes.

TABLE V

	(Per cent of oil separation) Pressure sensitivity	(Per cent of oil released) Oil bleed AN-G-3A	
		@ 150	@ 212
Calcium	0	7.3	....
Calcium modified	0	3.7	....
Calcium modified EP	0	6.4	....
Lithium	10.8	1.35	9.82
Lithium modified	8.9	2.47	4.12
Lithium modified EP	9.5	1.42	8.34
Sodium	26.8	13.5	24.2
Sodium modified	0	3.68	3.76
Bentone	0.51	1.48	5.54
Barium	0	3.19	20.3

In Table VII we show what can be expected under extreme pressure from the different soap and non-soap base greases with and without extreme pressure additives for those heavily loaded bearings in the bloomer, hot and cold strip mill. The Timken tester gives us good reproducable data as to what loads each grease can safely handle — results are expressed in pounds lever arm load. Our work has indicated that the addition of the necessary extreme pressure additives to pass the 33-lb Timken test breaks down the gel structure of the non-soap type of greases. Furthermore, extreme pressure additives in soda or water sensitive greases may result in formation of harmful by-products — therefore, we would eliminate soda type greases for that extreme pressure application.

The same amount of the same extreme pressure agents are used in the calcium as in the lithium. We get a definitely higher Timken pass on the calcium for the same amount of additive used.

We have employed the Falex machine to compare the wear characteristics of each type of grease under pressure but not under continual boundary lubrication conditions. First we determined the load carrying capacity on the Falex machine. In Table VII these results are shown in pounds gage pressure. The machine was run in at a 300-lb load and increased in steps of 50 lb each min until seizure occurred. The difference between Timken and Falex ratings we calculate is due to the Timken test having a constantly renewed supply of lubricant whereas the Falex operates for the full run with the original charge of grease.

From the test data it was noted that 450 lb was the lowest failure pressure. Therefore the Falex machine was set up and locked at 400 lb for the wear test and was run for 10 min or to the time of bearing failure. In Table VII results are reported in number of teeth wear of the combined shaft and blocks. Each tooth represents 21.8 microinches of wear. We believe the reason why the calcium greases showed no wear in contrast to some wear on certain other types can be attributed to the test temperature. We believe there was sufficient heat

TABLE VI

Pumpability (Pounds discharge pressure at 10 F)

Calcium	620
Calcium modified	780
Calcium modified EP	750
Lithium	760
Lithium modified	680
Lithium modified EP	650
Sodium	760
Sodium modified	750
Bentone	1310
Barium	1060

TABLE VII

	(Pounds on lever arm) Timken	(Pounds gage pressure) Falex load	(Teeth at 400 pounds) Falex wear
Calcium	16	1050	0
Calcium modified	14	1100	0
Calcium modified EP	56	1750	0
Lithium	14	450	6
Lithium modified	15	550	3
Lithium modified EP	39	650	0
Sodium	15	600	5
Sodium modified	18	700	3
Bentone	23	750	6
Barium	14	550	5

generated so that in the case of the calcium greases we exceeded their melting points and were running on an oil film at the point of contact.

In light of these results just shown you we would like to proceed to the many actual steel mill requirements and suggest the type of grease we think most suitable for each application. Please bear in mind that these are suggestions only and represent our experience with the various operations. We do not presume they approach perfection in lubrication — this can only come by the trial and error method between the grease manufacturer and you men who run and maintain this heavy equipment. In Table VIII we have tried to present the more important applications, surrounding conditions, and our recommendations.

TABLE VIII

Application	Principal conditions	Type of grease suggested
Koppers coke oven doors	Heat and dust	Bentone
Coke pushers and larry cars	Heat and cold, dust	Lithium or sodium (heavy oil)
Huelett unloaders	Cold and pressure	Calcium EP or lithium EP
Blast furnace top mechanism	Heat and cold, pressure	Calcium EP or lithium EP
Sinter plant pallet wheels	Heat and dust	Bentone or lithium
Open hearth cranes and chargers	Heat and cold, pressure	Calcium EP or lithium EP
Soaking pit cover mechanism	Heat resistance with slumpability	Lithium or sodium
Mills (plain bearings) bloomer—plate—bar—rod	Water—heat, pressure	Loss of oil by heat and water suggests graphite grease with high viscosity oil or lithium EP
Blooming mill or slabbing mill, A-F, roller bearings, screwdowns and shears, mill tables	Water—heat pressure	Calcium EP or lithium EP
Strip mill work rolls anti-friction backups	Pressure and water	Calcium EP
Cranes, edgers, scalebreakers	Heat and cold, pressure	Calcium EP
Electric motors	Oxidation—shear	Milled soda or lithium

Judging from our experience, therefore, we need a minimum of four distinct types of grease to get top performance, but if limited to this we are approaching simplification. These four types may have to be purchased in two or more grades because here again we say one grade will not serve all seasons. We have come close to an all weather lubricating oil by using viscosity index additives in the 10/20/30 and 5/10/20 multi-SAE oils. Perhaps we can eventually make an all weather grease by the use of these oils in connection with the various types of soap bases, but the cost is high and it has yet to be confirmed that the soap oil combination works in the same manner as the high viscosity index oil alone. Any plastic material such as grease is affected by temperature changes in degrees of plasticity or body as compared to oil in degrees of viscosity. Although a grease may pump at low temperature its change in consistency at higher temperatures may mean the breaking of a seal or loss of the lubricant.

We made both a calcium and lithium grease from the same viscosity oil as the greases just reported but increased the viscosity index from 70 to 100. We found that we hurt the pumpability probably because a high V.I. oil requires more gelator or soap to obtain the same grease consistency. On both the greases we required 900 lb discharge pressure at 10 F as compared with 600 to 700 lb with the 70 V.I. oil. The gel strength was not hurt at 150 F with the calcium 100 V.I. grease but at 200 and 250 F with the lithium, our results showed less gel strength than the standard lithium at the same temperatures.

Further research is urged to develop all weather greases so that we can have good pumpability at low temperatures with small changes in plasticity or body at high temperatures and still maintain the superior characteristics of a grease that will adhere, withstand pressure, and inhibit rust.

DISCUSSION

PRESENTED BY

D. E. WHITEHEAD, General Lubrication Engineer, Crucible Steel Co. of America, Pittsburgh, Pa.

J. S. AARONS, Lubrication Chemist, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

W. A. MAGIE II, Vice President, Magie Brothers Oil Co., Chicago, Ill.

WILLIAM C. BRYANT, Research Director, Magie Brothers Oil Co., Chicago, Ill.

D. E. Whitehead: The author renounces any inclination toward a philosophy of a universal or all purpose grease and has listed sound deterring considerations and we concur with his expressed opinions, however it is advantageous in many respects in arranging a lubricating grease selection for steel mill application to build a selection of greases around, and as supplements to, one large volume product of sufficient multi-functional qualifications to permit its wide general usage. This product, not all purpose in scope, is then over supported

by a selection of specialized greases to meet those extreme condition requirements. The injection of mid-range greases serves only to confuse the program and defeat the prime endeavor to keep the volume high and price minimized for those greases required and particularly for the basic multi-functional grease.

The calcium extreme pressure greases are generally selected as the basic multi-functional grease and we note its position well supported in the authors findings. The dual benefit of a proper extreme pressure additive in enhancing film strength and supporting resistance to oxidation has been pointed out. True homogenization rather than milling further stabilizes the calcium extreme pressure type. The addition of certain polar compounds adds much to their cohesive and adhesive capacities. Gradually these accomplishments have been made requiring much in research effort, a sample of which the author has brought to us in his paper, and yet adding little in manufacturing cost though adding much to the on the job fortitude of the calcium extreme pressure grease.

J. S. Aarons: The use of functional tests in evaluating greases is one of the most important items in the work done at the United States Steel lubricants testing laboratory. The painful lack of standard machines for testing greases which will correlate with field practice has been felt by all of us engaged in this work. In addition of this disparity, is the wide differences in procedures and interpretations of results obtained from these tests. My plea is for a conformism which would allow us all to standardize on these procedures and interpretations. I realize that such work is going forward under ASTM direction, but the wheels grind exceedingly slow.

Along this line of thinking I would like to ask the authors: 1. Do you feel that a ten min test is of sufficient duration for an adequate result using the Falex machine? I have found that greases of at least a consistency of 325 or higher should be used. A load of 500 lb, and a time duration of one hr has been found satisfactory in determining wear tests on greases. A decided channeling effect is produced in the greases at consistency ranges of 275 and as you have pointed out, the pin and block gets little lubrication. I would like to mention that each tooth on the ratchet wheel used at our laboratory is equivalent to 0.0000556 in. What limits do you put on acceptable wear characteristics for the Falex machine on greases? 2. Have you experienced any difficulty with the surface finish of the pins and the blocks that are used in this test?

W. A. Magie, II: I believe that perhaps we made a mistake in the Falex machine in not running much longer than ten min and probably going up to pressure. We did not want to approach boundary limits. We wanted to get wear. I would say anything up to 5 or 6 microns of wear is negligible. I have questioned putting this work in, because I do not think it has been used too much on grease, but we did some work back six or eight months ago on wear, using different extreme pressure additives and the Falex machine helped us. It also helped us to determine what was corrosive and what was not.

William C. Bryant: The Falex machine has been used for a number of years. I started out with it back in 1936 when it was known as the Cornell machine, and it has taken me 18 years to really come up to a workable operational technique.

It has been said that the Falex machine, using the Bryant technique of operation, was the only one that Technical Committee C of ASTM on turbine oils found to give relative curves on all oil ratings for other than extreme pressure oils. The regular Falex test procedures, where they use large increments of pressure, and the Timken machine gave no correlative values whatsoever.

In the paper we passed over several test method descriptions, hoping questions would come from the floor. We could then cover the test method descriptions to those interested in the test methods during the discussion period.

Where we stated that we began the Falex test at 300 lb, that was for 180 sec, namely three min. That was to make sure that any of the high spots on the surface finish of the shafts and coined blocks would be reduced. We did not measure any wear until we passed through the 350-lb pressure. We applied 50 lb per min as a step test. In other words, within the first four sec, the ratchet and pawl would bring the pressure from 300 to 350 and so on up the line until we reached 400 lb pressure, applying the load in 50-lb increments.

We noted the wear that would occur in that step-up procedure, but it was disregarded in the test procedure because we felt still again we were only removing the high spots on the finish of the metal parts. We locked the pressure at 400 lb and did not take any torque measurements. The whole system was locked tight and as the wear was indicated by drop in pressure we took up by the ratchet and pawl the number of teeth necessary to bring up the pressure to 400 lb.

We definitely did find that the surface finish of the bearings gave us indications as to the amount of wear on the 10-min period. Any test sets that needed more than 15 teeth take-up in the one min, 50-lb step period were discarded and the test rerun. I think we threw out about 25 tests in the whole series, however, when we got the break-in period wears below 15 teeth, there were correlations within one tooth on the 10-min period.

Now why did we suggest the 10-min period? It was arbitrary. On most of the wear tests, such as are found in certain automotive specifications where the Falex machine is stipulated, their wear periods are 10 min at the pressure. Mr. Aarons mentioned that he used higher pressures and longer periods of time. You must realize we were correlating non-extreme pressure and extreme pressure greases. The lithium grease showed from the film strength test where torque measurements were made, but not recorded here, that 450 lb was the film strength of that grease. Therefore, in order to obtain the wear test we do not go to 500 lb.

On Mr. Aarons' comment about the consistency of the grease needing to be 325 or higher to prevent channeling, we will agree.

We reported the gel strength data in penetrations at 77 F, as indicated by the 58-gram cone. They were equivalent to penetrations of 335 to 345, therefore No. 1 consistencies. We did not get the high channeling that we would have obtained with the No. 2 consistency.

We feel we should continue this work, as a whole, much further and I am sure we will come up with answers on the Falex.

CONTINUOUS DRAWING of Cold Finished Bars

By WALTER J. PROCHAK
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. . . . by revamping a cold drawing setup into a continuous operation, handling is reduced, yield is increased, maintenance is less, hazards are practically eliminated and operating crew is reduced about 40 per cent . . . .

▲ STREAMLINING of manufacturing processes through the modification of production equipment is the aim of all producers to meet the demands of our times. Old production methods in many cases are cumbersome and inefficient. In order to meet the present day consumer demands, emphasis is placed on quality, speed of production and efficiency of production. As an illustration, the present day open hearth furnace has been basically the same for approximately 86 years. However, modifications through the years have greatly increased its efficiency and the quality of steel it produces.

The art of producing cold finished bars from hot rolled steel is probably one of the oldest arts known to man. The present method of cold drawing by use of a die is believed to have been originated in Germany during the middle of the 14th century and production by machine operation was initiated in England in 1565. The art was introduced in the United States in about 1831 when Ichabod Washburn and his associates founded Washburn Moen and Co. of Worcester, Mass. Their original rod drawing mechanism pulled the rod through the die five inches in one stroke. This machine was progressively improved until it drew fifteen feet at a stroke. Still further improvement of cold drawn equipment resulted in the practice of drawing rods directly onto rotating blocks. The production of straightened and cut-to-length bars from drawn coils was the final step in producing cold finished bars from hot rolled coils.

Today's mass production of precision parts with high speed automatic screw machines, requires a material that can be produced economically and in large quantities. Cold drawn bars combine straightness and accuracy to a degree that fills the requirements of close tolerance on sections of the bar which are not machined. The finish allows it to pass smoothly through the intricate feed mechanism of the automatic screw machine without jamming or injuring delicate parts. Also, by lowering ductility and by producing a desirable microstructure, cold drawing increases the machinability of the steel.

Figure 1 — Rounds, hexagons and squares were machine pointed on the unit shown in operation.

Figure 2 — The bull block allows long lengths to be cold drawn.

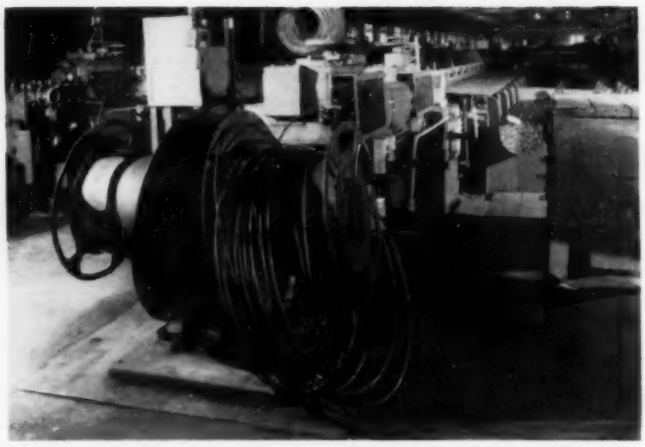


Figure 3 — Straighten-and-cut machine for round bars had driven feed rolls, a spinning arbor, driven exit rolls and a flying shear.

It is the intention of this paper to describe the design of a production line with maximum speed and economy for the output of ¼ to ⅝-in. cold finished bars. These bars involve a number of shapes including rounds, hexagons, flats and squares. The development of this production line modernized an operation which in its origin consisted of the following three fundamental operations:

1. Pointing.

Individual hot rolled, pickled and lime-coated coils ranging from 150 to 600 lb in weight were machine swaged or machine pointed so that the point would pass readily through the opening of the die. Rounds, hexagons and squares were machine pointed on a No. 4 pointer. This machine had a rotating head which was equipped with adjustable cutting knives. Flats were swaged on a swaging machine which had off-center rolls that could be preset for desired width and thickness. A 1000-lb capacity jib crane was used to transport the coil to the pointing machines. The jib crane, with a hoist equipped with rollers could be positioned at will over the work area. Figure 1 shows the two pointing machines with the No. 4 in operation.

2. Drawing on the bull block.

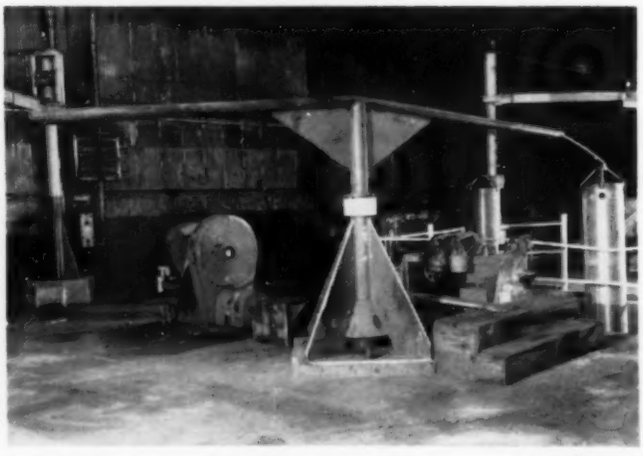
After the pointing operation, the coil was transferred by the jib crane to a horizontal reel for the drawing operation. The bull block consisted of a power driven cylindrical drum which contained a jaw-type grip fastened to a chain anchored to the drum. The pointed coil end was passed through the drawing compound and the die, and then was secured in the grip. As the drum rotated, the coil was pulled through the die onto the block. The draft or reduction normally ranged from $\frac{1}{32}$ to $\frac{1}{16}$ in. depending on the size, shape and grade. Figure 2 shows the coil being drawn onto the bull block.

3. Straightening and cutting.

Following the drawing operation, the grip was disengaged from the coil point. Then the coil was again lifted by the jib crane and transferred to the dual vertical feed reels of the round or shape straighten-and-cut machine. The straighten-and-cut machine for round bars consisted of driven feed rolls; a spinning arbor which contained soft metal dies; driven exit rolls; and a flying shear. A run-out trough was attached to the end of the machine, so that as the bar passed through the shear eyelet, the bar was guided to the shear tripping mechanism which was preset to the desired length. The shape straighten-and-cut machine was basically the same as the round straighten-and-cut machine with the exception that it did not contain a spinning arbor. In place of the spinning arbor, one machine was equipped with eight horizontal driven and eight vertical driven straightening rolls. Figure 3 shows the drawn coil being straightened and cut to length.

The installation as described, offered considerable flexibility in selection of processing units, but it was extremely limited in production speed as well as being expensive from the standpoint of material yield and manpower. It readily can be seen that this method was a time-consuming operation due to preparation and handling. The yield was not considered satisfactory since approximately two to three feet were scrapped from the front end of each coil because of the point and the length necessary to obtain proper size. The whipping action of the coil end as it left the feed reel necessitated scrapping an additional ten to fourteen feet of the coil. This whipping action was encountered only on round bars. The scrap loss was somewhat less on shapes. Also, a considerable amount of the bar and some time was lost due to die scratches obtained from

Figure 4 — The welding rack consists of a turn-around located above the welding unit.



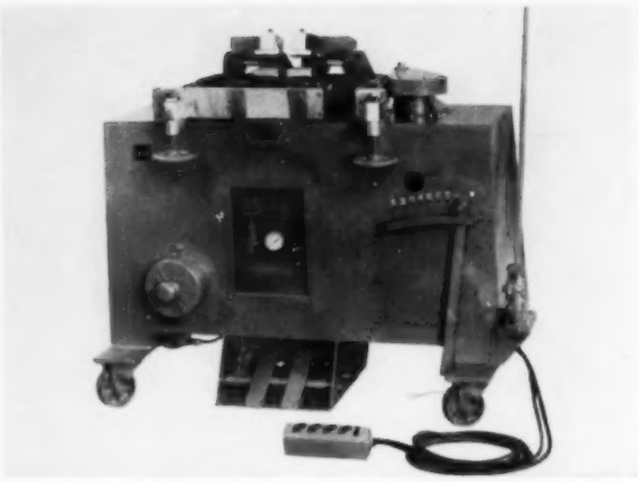


Figure 5 — Welding unit is a motor driven flash welder.

burrs that were caused by excessive pointing. Normally these operations required the services of four to five men depending on the size, shape and grade being processed.

With increased demand for production, along with more extensive orders covering individual sizes, it was readily apparent that a modification of the production line was necessary.

After considerable study of various layouts of the operation, a plan for a completely streamlined continuous processing operation was developed. This study lead to the present layout of four separate and individual processing lines consisting of the following:

1. Welding rack.

The welding rack, which supports the coils and is called a coil turnaround, is a revolving "T" shaped rack mounted on a pedestal of sufficient height so that the suspended hot rolled coils clear the welding unit which is located beneath the arms of the turnaround. The arms of the turnaround are sloped slightly downward to facilitate coil removal once the welding operation is completed. Figure 4 shows the welding rack.

2. Welding unit.

The welding machine used to join the coil ends is a motor driven flash welder. Its capacity is ¼ to 1-in. diameter coil stock. It is a variable controlled current, time and speed flash-type welder consuming high amperage current. It is equipped with groove type grip vises that consist of copper dies to conduct the high current more readily through the coil stock which is placed in the copper dies. The vise is air operated, actuated by a foot controlled lever. The selection of the various current, speed and time settings are governed by the grade and size of steel that is to be welded. Through practice it has been found that the larger diameter stock requires a longer flash weld time than the smaller diameter stock, and also the current required increases for the larger sizes. The welding machine is shown in Figure 5.

The coil ends are placed into the grooved dies and alined with the ends touching as shown in Figure 6.

A remote controlled switch is provided so as to keep the operating personnel in the clear of the unit as the flash is produced. One of the vises is motor driven to force the coil end against the other coil end at the same time that the current is applied. This results in a large outwardly forced flash. This operation is illustrated in Figure 7.

At the end of the weld cycle, an upset is formed as a result of the inward movement of one coil end against the other, and causes excess molten steel to be extruded. Part of this excess flash can be removed with a chisel type hammer that is provided to the personnel. The balance is ground down with an air operated, high speed hand grinder. The weld is ground down to slightly under the original size of the bar to lessen the work on the weld as it passes through the die, and is marked with paint or hot metal chalk in order to identify the area that was welded. Figure 8 shows the resulting fin and hand grinder for its removal.

3. Feed reels.

The original feed reels were modified with extensions to accommodate up to eight 600-lb hot rolled coils welded end for end. These modified feed rolls, known as "hi-hats," are free to revolve on a bearing ring as the coils are being processed. With these modifications the new line is ready for continuous operation.

The pickled and lime-coated hot rolled coils are placed on the arms of the turnaround by means of overhead shop cranes equipped with a coil yoke. Each arm accommodates approximately eight 600-lb coils. The coil tie wires are removed from each coil prior to

Figure 6 — Prior to welding, coil ends are alined and the ends butted together.

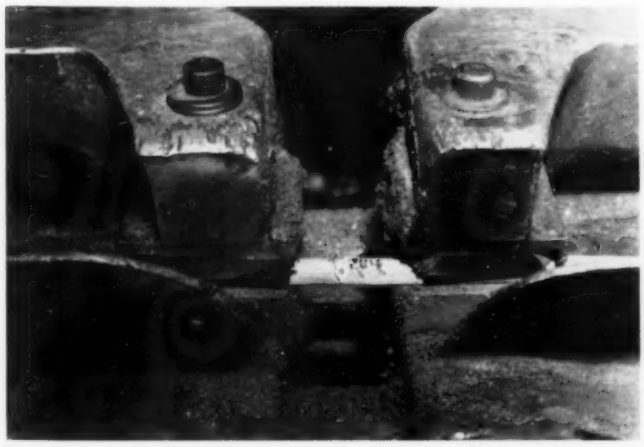


Figure 7 — Remote control keeps personnel clear of the flash.

Figure 8 — Pressure exerted during welding creates an upset, some of which can be removed with a chisel type hammer.

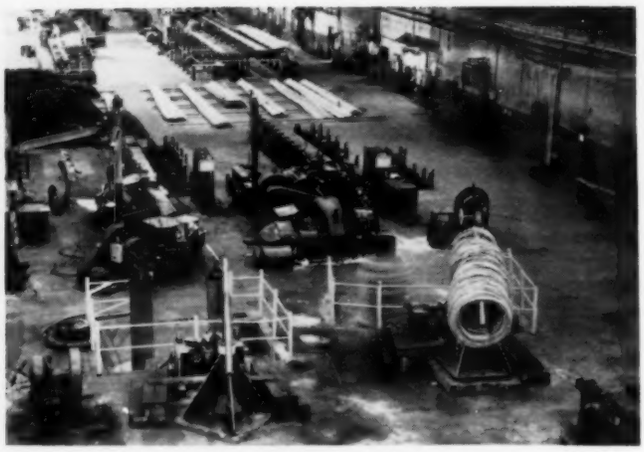


Figure 9 — The various components are synchronized to operate as a continuous production line.

welding of the ends. As each weld is made, the preceding coil is transferred to the hi-hat by means of a turnaround arm guide extension engaged to the top of the hi-hat. There are two hi-hats located in front of the welder to accommodate the coils from each arm of the turnaround. The lead end of the uppermost coil on the hi-hat is pointed to facilitate processing through the die. The coil is then drawn onto the bull block a sufficient number of wraps to obtain traction and is then fed into the straighten-and-cut machine. Once the first hi hat is spent, the trailing end of the last coil is welded onto the lead end of the uppermost coil of the second hi-hat and the drawing operation is continued. Once the cold drawn coil is started through the straighten-and-cut machine, the speed of both units are synchronized by the operator. Figure 9 shows a general view of the continuous production line.

Originally this continuous production line was used for rounds and hexagons ranging from $\frac{5}{16}$ to $\frac{5}{8}$-in. in size. By modifying the vise clamp dies of the welder, it was possible to process $\frac{1}{4}$ to $\frac{5}{8}$-in. squares and flats ranging from $\frac{1}{4}$ to $\frac{3}{8}$ in. thick and up to 1 in. in width. Bessemer grades in rounds and hexagons; and low to medium carbon and alloy grades in rounds, hexagons, squares and flats are all processed by this method.

SUMMARY

1. The handling problem has been greatly reduced. The old method required handling of individual coils during the various stages of processing, whereas the new method allows the processing of coils in groups.

2. The yield has been increased. Under the old method, approximately three feet were scrapped from the front end of each coil because of the point, and approximately ten to fourteen feet from the back end of each coil were scrapped due to the whipping and marring action of the coil as it left the bull block.

3. The electrical and mechanical maintenance time has been reduced. Repairs on the jib cranes were eliminated. The new method resulted in less wear on the block drum and less mechanical maintenance on the straighten-and-cut machine.

4. The safety hazards have been practically eliminated. Minimizing the number of individual operations which reduced individual handling, greatly lowered the number of hazards of processing.

5. The operating crew was reduced approximately forty per cent. Since the individual handling operations were reduced, less men were required to process the stock under the new method.

STATISTICAL QUALITY CONTROL IN THE COKE PLANT*

▲ THE basis of statistical quality control is that there is an inherent variation in the measured quality of any manufactured product. Variation within this pattern of measurement is inevitable. Any variation other than the inherent variations can be studied and methods devised to correct them. Any variation within the normal pattern is an intrinsic part of the operation.

There are three methods of recording the data that are commonly used in quality control. These are:

1. The Shewhart control charts for variables. These are used for charting quality indexes that are measurable and are commonly called $\bar{X}$ and R charts, or X and σ charts.

2. The Shewhart control charts for fraction defective. These are used where many individual items are produced and defective pieces must be rejected. They are usually called the p charts.

3. The Shewhart control charts for defects per unit. These are used where the defective parts of the unit can be repaired or replaced. They are called c charts.

The use of the Shewhart control charts is very attractive because of their simplicity.

One of the big advantages of this method of presenting data is that definite values are set on what is good control and what is not. It does not say that we should be able to produce a given quality; it says that this is what we *are* producing. If the quality index is not satisfactory, it points out ways in which it can be corrected.

Sometimes the economics of the situation compel us to live with a condition that is not satisfactory, but the control chart will still tell us what we can do with the equipment available and help us iron out deviations that should not occur in the equipment we have.

*From paper by Robert E. Franks, Inland Steel Co., East Chicago, Ind., presented at Blast Furnace, Coke Oven and Raw Materials Conference, Philadelphia, Pa., April 19, 1955.

By ROBERT W. WORLEY, Engineering Manager, United Engineers and Constructors, Inc., Philadelphia, Pa.

New Steam and Power Facilities— Ohio Steel Works, U. S. Steel

. . . . an economical solution to the problem of increasing power and steam at the Ohio works involved use of some existing buildings and equipment and a minimum of interruption to operations . . . . new steam generating units are fueled with blast furnace gas . . . .

▲ REPLACEMENT of gas engine driven generators and blast furnace blowers with steam driven units naturally involved the problem of steam supply. Thorough study of several plans resulted in a decision to install two new high pressure boilers and a topping turbine. This turbine exhausts into the plant 280-psi steam system.

In developing the layout for the new equipment, it was decided to install the turbogenerator in the existing power house in space then occupied by gas driven engines which had been taken out of service. Further analysis developed that the boilers could be installed in an existing adjacent building. This made possible the use of a substantial brick building with a bare minimum of repairs and changes, and avoided demolition expense.

Once the decision to use the existing building was made, layout plans were developed which indicated that an existing air compressor and receiver and water pumps could be left in their original location. One bay of building was adequate to house the new water treating equipment and the two boilers were installed in the next four bays, providing ample clearance for walkways and access platforms and still leaving space for a future boiler at one end.

EQUIPMENT INSTALLED

Two steam generating units have been installed, each having a guaranteed capacity of at least 250,000 lb per hour of steam at 950 psi, 900 F and arranged for burning blast furnace gas. Provision was made to add other gas or fuel oil or both if required in the future.

Each steam generator is equipped with pendant type superheater, economizer, tubular air heater, steam temperature control, boiler blow-off and continuous blowdown, conductivity meters to guide boiler water concentration control, flame failure alarm, four blast furnace gas burners, soot blowers, and one forced draft and one induced draft fan. The fans are turbine driven to make the station independent of power failure, and the exhaust steam from the turbines was required for feed water heating.

Modern steam generating units, operating at high steam pressure and temperature, require feedwater of very high quality, free of those constituents which form scale or cause foaming and priming in the boiler.

The water treating equipment is at the south end of this building. This system is known as a hot lime—hot zeolite system, having a treating capacity of 400,000 lb per hr. This consists of a spherecone sedimentation tank where primary treating is done by reaction of lime and hot water. Water flows from sedimentation tank through filters and is then pumped through hot zeolite softeners where residual hardness is reduced to zero. The water is then delivered to a deaerating heater located at an elevation of 41 ft above the feed pumps. Condensate returned from the condensers of two 280-psi condensing turbogenerators and from turboblower condensers is also delivered to the deaerating heater.

Raw makeup water delivered to treating system is obtained from Ohio Water Service Co. mains. This is used as cooling water in turbogenerator auxiliaries before coming to the boiler house. An emergency supply

of water is provided by a connection to Youngstown city water mains, and a connection is provided to permit use of river water as a last resort.

Three barrel type boiler feed water pumps are installed at basement floor level. Each of these pumps is rated 800 gpm (approximately 400,000 lb per hr) at a discharge pressure of about 1300 psi. Suction to these pumps comes from the elevated deaerating heater with a static head of approximately 30 ft water and temperature of 225 F. These pumps operate at 3560 rpm. Turbine drives for feed water pumps are 800 hp each. These turbines are provided with hand valves to make operation possible in case of low steam pressure.

All turbines for mechanical drives in the station operate from 280-psi plant steam system and exhaust into the 5-psi steam line supplying heating steam to softener and deaerating heater. A multiport atmospheric relief valve prevents excessive pressure in this line.

To insure complete elimination of scale forming salts in boiler water, pumps are provided which inject predetermined quantities of phosphate solutions directly to boiler drums. This is controlled by periodic chemical checks of boiler water.

Automatic boiler control is provided for both boilers. This control system is of the air operated type and includes combustion control and feed water control. The operation is based on metered quantities of fuel, air and steam flow and steam pressure. The controls and meters are centered on a master control panel and two boiler control panels located on the operating floor in front of the boilers.

Pressure reducing and desuperheating stations are provided as a bypass in the event the turbogenerator is out of serivce or not up to load equivalent to steam demand. Three complete pressure reducing and desuperheating stations are installed, each with air operated automatic and remote manual controls. Controls and meters for operation of this equipment are mounted on the control panel located on the operating floor. Each unit of pressure reducing and desuperheating equipment has a capacity for handling 300,000 lb of steam with inlet steam of 950 psi, 900 F temperature and outlet at 280 psi, 600 F temperature. Pressure control is from the 950-psi steam header. This is designed to operate the pressure reducing valves as "spill over" valves, that is, the PRV's will open upon rise in pressure of the 950-psi steam header and discharge steam to the 280-psi system. Variations may be made in setting the relieving pressure.

Desuperheaters are of the steam atomizing type with automatic control valves in the water and the steam lines to each desuperheater. Each water control valve is positioned by the temperature controller to proportion the flow of water as required to maintain constant temperature in the outgoing 280 psi steam.

Water of good quality and at high pressure is required for the desuperheating spray nozzles. Condensate will normally be used, supplied from a condensate storage tank and by a turbine driven desuperheating water pump. An emergency supply can be obtained from the high pressure boiler feed header through a pressure reducing valve which will automatically cut into service in the event of a drop in pressure due to failure of the desuperheating water pump.

Piping for the 950-psi steam system consists of all welded end alloy steel valves and chrome molybdenum pipe. A common 14 in. header was installed to which a 12-in. steam line from each boiler superheater outlet header admits steam, and from which a 14-in. line takes steam to the turbogenerator in the adjacent power house. Appropriate sectionalizing valves have been provided to permit necessary maintenance without complete shutdown. Motor operated valves are provided in boiler and turbine leads to permit quick isolation of lines if this is required.

All other steam piping is carbon steel.

Blast furnace gas is taken from a gas main common to all furnaces. Gas for the boiler house passes through two electrostatic cleaning units, each having a capacity of 90,000 cfm, which cleans the gas to 0.015 gr per cu ft. The gas is then delivered to the boiler house where separate gas mains are run to each boiler. As the pressure in the main varies over a wide range, butterfly valves are installed at each boiler as part of the combustion control system which also serve to maintain proper gas pressure to burners.

Natural gas is used for pilot burners in the boiler blast furnace gas burners, and is supplied through a 6-in. line from the plant natural gas system. As the incoming natural gas pressure varies widely, a pressure control valve is provided in the line which is adjusted to maintain outlet pressure at 8 to 10 psi.

In addition to the above equipment, there are various pumps, both turbine and motor driven, a water testing laboratory and chemical storage rooms, air compressors to supply air for instruments and control, and other items required in the new boiler house which need not be discussed further.

The new topping turbogenerator No. 3 has been installed in the a-c power house. This new unit supplements condensing turbogenerators No. 1 and No. 2, each of which are rated 15,000 kw, and replaces the old gas engine generators being retired from service.

The new turbogenerator unit is composed of a noncondensing turbine with inlet steam 900 psi, 900 F and exhausting at 280 psi, a speed reducing gear and electric generator with direct connected exciter. The unit is rated 15,000 kw (18,750 kva), 3 phase, 25 cycle, 6600 volts.

The turbine is a horizontal unit having 10-stages, babbitted sleeve bearings, thrust bearing, labyrinth type shaft packing glands at high and low pressure ends and steam inlet valve gear, and furnished with the usual standard accessories and complete lubrication system.

Oil conditioning equipment is installed to maintain a constant supply of clean oil for turbine lubrication and control systems.

Temperature monitors are installed in all bearings of the main turbine generator unit. This equipment automatically and successfully checks the temperatures of the various bearings. If the temperature varies beyond a predetermined limit, an audible alarm is sounded and an announciator on the turbine control panel is actuated.

Steam for No. 3 turbogenerator is supplied for the new high pressure boilers. This turbine exhausts to the existing 280-psi plant steam system, which supplies steam to turbogenerators No. 1 and No. 2. When the new generating unit is out of service or not taking full boiler capacity, high pressure steam can be passed through pressure reducing and desuperheating stations.

Exhaust from turbine is a 20-in. carbon steel line which connects to the existing 280-psi system. A motor operated shut-off valve is installed in this line just ahead of the connection to the plant system. The operation of this valve may be controlled by pushbuttons located adjacent to the valve and on the turbine control panel.

Three relief valves vented to atmosphere are installed in the exhaust line between the turbine and the motor operated shut-off valve. The combined capacity of these safety valves will exceed the maximum total steam flow through the turbine.

The 20-in. exhaust from the turbine generator is equipped with desuperheating equipment to reduce the steam temperature. Condensate will be used normally for desuperheating and obtained from the desuperheating water pump in the boiler house. The temperature controller is set to maintain steam temperature at 600 F.

In conjunction with the new electric power generating facilities it was determined that the control, switchgear and excitation systems for the two existing 15,000-kw turbine generators were obsolete and should be replaced. The control, metering and relaying was inadequate and it was physically and electrically impractical to provide centralized control and switching for both the existing generators and the new generator without complete relocation.

To completely replace the existing switchgear and control equipment and at the same time coordinate the addition of the switchgear and control equipment for the new generator all with limited power outages presented a difficult problem.

It was determined that a separate control and switchgear building would be constructed inside the a-c power house. The building was designed as a three story structure with the synchronizing bus with its reactors and the feeder reactors installed on the first floor, switchgear on the second floor, and control, metering and relay equipment on the third floor. The control room on the third floor was provided with large observation windows which provide a good view of the complete station.

In the control room is the benchboard which permits control and synchronizing for all three generators, synchronizing bus and excitation equipment. The main and auxiliary duplex boards provide control for all feeders and auxiliaries and incorporate all instrumentation, metering, relaying and alarm identification. An operators desk is provided with indicating wattmeters for all feeders, generators and total generation. Included is a master alarm panel and a communication system. Also provided is a telemetering panel which furnishes wattmeter indication for each of eleven feeders at the McDonald Mills. A recording demand meter panel board is also provided with selector switches to permit the recording of a 5, 10 or 15-minute demand from any preselected feeder.

Complete protective relay schemes are provided and include differential, overcurrent, ground, power directional, loss of field, etc.

The metal-clad drawout switchgear located on the second floor is rated at 6600-volt, 3-phase, 25-cycle, 500,000-kva interrupting capacity.

New excitation switchgear and voltage regulating equipment is provided for the new and existing generators. A spare exciter, (with excitation switchgear and rotating voltage regulator) is provided for use with any of the three generators.

A new carbon dioxide fire protection system was provided for generators 1 and 2, and a separate similar system for the new generator No. 3. The systems operate automatically by operation of either the fire detection thermostats or the generator differential relays.

Power is generated at 6600 volts and utilized directly for various plant loads. Power is also transmitted, through step-up transformers, at 44,000 volts to the McDonald Mills. Step-down transformers provide power at 440 volts for station auxiliaries.

The high bay lighting in the turbine room consists of 3000-watt mercury vapor units with partial color correction being accomplished by intermixing 1000-watt incandescent units with the mercury vapor units.

New operating procedures, as well as new equipment, have been introduced by the power house installation. It was, therefore, decided that an operator's school should be held prior to preliminary operation of this plant to assist all personnel, including operators, maintenance men and supervisors, to become thoroughly familiar with the equipment as installed, and the procedure to be followed.

One week was set up to thoroughly explain manuals provided for each operator, which gave a description of all boiler house equipment and the operating procedure. This was followed the second week by representatives of manufacturers of equipment who discussed in detail the operation of their equipment. Both boiler house and power house personnel attended these sessions. A third week was used to present descriptions of equipment operating procedure, and detailed instruction for turbogenerator and electrical switchgear. The time, effort and cost for this training period has proven very valuable. This plant was put into operation with a minimum of usual difficulties and the operators had a high degree of confidence made possible by this training.

DISCUSSION

PRESENTED BY

J. P. KATZENMEYER, Project Engineer, United States Steel Corp., Youngstown, Ohio

J. P. Katzenmeyer: In addition to the splendid description of the new steam and power facilities just presented, there are a few additional items worth noting.

It was mentioned that raw water was used as cooling

water for the new topping and the two condensing turbogenerators, thus picking up heat before going to the boilers. Previously, this water flowed through the coolers of the two condensing turbogenerators under Ohio Water Service supply pressure and drained into a hot well. From this well, it was pumped into a standpipe which supplied cooling water for the seven gas power engines, just replaced by the new generator, and four gas engine blowers. The engine cooling water then supplied all of the Ohio Works boilers. In the new system, booster pumps pick up the water as it enters the plant and pump it through all coolers on the three turbogenerators from which it goes to the suction side of the raw water pumps which supply water for all the Ohio Works boilers. Thus the old standpipe and well have been eliminated along with the danger of low water pressure.

With reference to Mr. Worley's statement that considerable money was saved by utilizing an existing building for the new boilers, it may be interesting to note that an existing 96-in. blast furnace gas main was also utilized. The main runs from the blast furnace area to a header running between the powerhouse and boiler house. Washers, now removed due to the new precipitators, cleaned the gas for the seven gas power engines and four gas blowing engines. A gasholder, located at the washers and also removed, regulated the gas pressure in the header for proper ignition of the engines. An operating problem was foreseen, that during the start up period of the new boilers and generators, and before the old gas engine could be shut down, an extreme gas pressure variation would exist in the blas furnace gas header due to increased and variable gas flow caused by the new boilers. This would cause the engines to lose ignition. The gasholder could not be utilized because the higher pressure, necessary due to increased flow, would blow the seals. To solve the problem, an air operated "swing through" type butterfly valve was installed downstream of the precipitators with its control impulse point located in the header between buildings close to the gas engine take offs.

Every new installation invariably has something happen that is unusual. The new boilers have pendent type superheaters that are non-drainable so that once water is added for the hydrostatic test, it will lay in the superheater tubes until the boiler is fired. Usually the hydrostatic test is made before the water treating facilities are ready for operation thus untreated water is used, but without concern of damage due to corrosion because the boilers are normally fired within four to six weeks. However, immediately after the hydrostatic test of these new boilers, all work was stopped due to a trade union strike. This caused considerable concern, as the length of the strike could not be determined, so our feed water consultant recommended the use of hydrozene hydrate, which will remove any oxygen that is present in the water. One pound of concentrated hydrozene hydrate per 1,000 gal of condensate, giving a concentration of approximately 50 ppm, was pumped through the superheater of each boiler six times thus tending to flush the hydrostatic test water out and leave a small concentration of hydrozene hydrate to guard against corrosion. Before starting the boilers a sample was taken from the superheater header drain that indicated there was still hydrozene present but at a lower concentration than originally put in. Therefore, it is believed that no corrosion took place. It may be interesting to know that tests are presently being conducted to determine if hydrozene hydrate is superior and more economical than sodium sulphite in removing oxygen from boiler feed water.

Changes in the plant boiler feed water facilities, which are now being accomplished, were occasioned as a direct result of the new boiler house and should be of interest. Since it is desirable to utilize all available condensate in the new 950-psi boilers, the make up in the feed water for No. 9 boiler house was increased from 50 to about 90 per cent. This did not cause the capacity of the old treating facilities to be exceeded because they formerly supplied No. 8 boiler house, which was abandoned, but it did give the boilers in No. 9 boiler house a poorer grade of feed water than before. To remedy this a 12-in. line is being run to connect the new treating facilities to the deaerating heater at No. 9 boiler house thus permitting the normal excess capacity of zeolite water to be used at No. 9 boiler house except when condensate is lost due to a turbogenerator, and/or, a turboblower being out of service, making it nesessary to use all of the zeolite water at No. 10 boiler house. In addition, the old treating facilities, which consist of two lime-soda softeners and four filters, are being modernized as much as possible to attain a better treated water.

It might also be well to mention that the intended plan of operation is to base load the new boilers to their limit as long as blast furnace gas is available, and allow the excess steam to spill over into the 280-psi system. Any excess gas beyond the new boiler house capacity can be burned in No. 9 boiler house where there exists four combination blast furnace gas and pulverized coal-fired boilers.

In addition to Mr. Worley's statement that the control, switchgear and excitation systems for the existing turbogenerators were obsolete, it is well to add that they were old and badly worn and of inadequate capacity to interrupt the maximum fault currents. Portions of the switchgear had been rebuilt once and even twice, but was still deficient in interrupting capacity, and therefore its complete replacement was necessary in order to insure uninterrupted electric power for the Youngstown District. The location of the new switchgear, which was completely removed from the old switchgear, made it possible to maintain district power requirements without loss of production during tie-ins.

Engineering was started from scratch. In spite of this fact and others, such as fifteen weeks lost due to strikes, co-ordination of a number of different erection contractors, purchase of a wide variety of equipment, coordination of deliveries from numerous suppliers, installation of the new generator with gas engines operating within a few feet on both sides, and numerous tie-ins with existing facilities while the plant was operating at full capacity, the new facilities were operating within twenty-two months after the appropriation was approved.

Tentative Program

ASSOCIATION OF IRON AND STEEL ENGINEERS

1955 AISE CONVENTION

HOTEL SHERMAN
CHICAGO, ILLINOIS

September 26, 27, 28 and 29

"Oxygen Steelmaking Practice," by C. R. Austin, Manager, Oxygen Steelmaking Process Div., Kaiser Engineers, Oakland, Calif.

"The Installation of and Split Wind Blowing With Topping Turbo Blowers for Blast Furnaces," by E. O. Austermiller, Chief Engineer, and W. A. Smith, Superintendent, Power and Fuel Dept., National Works, National Tube Div., United States Steel Corp., McKeesport, Pa.

"Heating Heavy Sections — How Fast?," by Quentin Bloom, Project Engineer, Selas Corp. of America, Philadelphia, Pa.

"A Practical Approach to a Fuel and Lubrication Problem," by C. R. Burton, Superintendent of Maintenance, Hibbing-Chisholm District, Oliver Iron Mining Div., United States Steel Corp., Hibbing, Minn.

"Additives in Steel Mill Lubricants," by M. S. Clark, Chemist, Research and Technical Dept., The Texas Co., New York, N. Y.

"The Continuous Annealing of Tin Plate Strip," by Horace Drever, President, Drever Co., Bethayres, Pa.

"Modernization of the Hot and Cold Continuous Strip Mills, Bethlehem Steel Co. — Lackawanna Plant," by F. S. Eckhardt, Chief Engineer, Lackawanna Plant, Bethlehem Steel Co., Lackawanna, N. Y.

"Welded Structures as Applied to Cranes and Mill Equipment," by I. W. Evans, Chief Welding Engineer, Morgan Engineering Co., Alliance, Ohio.

"Protective Coal Tar Coatings in Steel Plants," by Dr. W. F. Fair, Jr., Coatings Consultant, Tar Products Div., Technical Dept., and H. J. Cibula, Sales Representative, Tar Products Div., Sales Dept., Koppers Co., Inc., Pittsburgh, Pa.

"Experiences in Purging Plants and Mains," by Hugh E. Ferguson, Chief Testing Engineer, The Peoples Gas Light and Coke Co., Chicago, Ill.

"Improved Mill Performance Through Modernized Electrical Control," by E. B. Fitzgerald, Assistant Division Manager, Industrial Control Sales, and Eric Pell, Engineering Supervisor, Cutler-Hammer, Inc., Milwaukee, Wisc.

"Balanced Pressure Coke Oven Gas Distribution," by H. V. Flagg, Combustion Engineer, Armco Steel Corp., Middletown, Ohio.

"Developments in Steam Generation for Steel Plants," by F. X. Gilg, Executive Assistant, Boiler Div., The Babcock and Wilcox Co., New York, N. Y.

"Developments in Scalebreaking and Continuous Pickling Lines," by J. I. Greenberger, Group Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

"Rectifier Equipment to Supply D-C Power in Steel Mills," by C. S. Hague, Manager, Power Conversion Section, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

"Recent Developments in Sintering and Pelletizing," by Edwin N. Hower, Manager, Industrial Dept., Dravo Corp., Pittsburgh, Pa.

"Fans for Iron and Steel Mills," by Robert Jorgensen, Assistant Chief Engineer, Buffalo Forge Co., Buffalo, N. Y.

"Steam-Fuel Ratio Control as Applied to Open Hearth Furnace Operation," by W. H. Kahl, Combustion Engineer, Open Hearths, Inland Steel Co., East Chicago, Ind.

"Normalizing and Quench-and-Temper Heat Treatment of Steel Products," by James MacGregor, Board Chairman, York-Gillespie Manufacturing Co., Pittsburgh, Pa.

"Layout and Design of Ingot Mold Foundries," by Glenn W. Merrefield, Foundry Engineer, Giffels and Vallet, Inc., Detroit, Mich.

"Electrostatic Application of Materials in the Steel Industry," by Dr. Emery P. Miller, Director of Research and Development, Ransburg Electro-Coating Corp., Indianapolis, Ind.

"Factors in Solvent Selection and Control of Hazards in the Steel Industry," by John B. Moore, Technical Director, John B. Moore Corp., Nutley, N. J.

"The Practical Approach to Coil Splicing," by R. E. Morton, Vice President and General Manager, Morton Manufacturing Co., Muskegon Heights, Mich.

"Oil Mist Lubrication and Some of Its Applications in the Steel Industry," by T. M. Murphy, Manager Industrial Sales, Alemite Div., Stewart-Warner Corp., Chicago, Ill.

"Underhearth Cooling of the Bottom of Blast Furnaces: Temperature Distribution and Heat Extraction," by Victor Paschkis, Technical Director, and Taghi Mirsepassi, Research Assistant, Heat and Mass Flow Analyzer Laboratory, Columbia University, New York, N. Y.

"Ideal Maintenance Machine Shop Facilities," by W. J. Pearson, Machine Tool Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Lubrication — Systems and Applications at Fairless Works," by W. E. Rigot, Lubrication Engineer, United States Steel Corp., Fairless Hills, Pa.

"Local and Interplant Gas Dispatching in Steel Plants," by H. J. Rohm, General Coordinator, Fuel and Power, United States Steel Corp., Pittsburgh, Pa.

"Tonnage Heating by Induction," by R. S. Segsworth, Director of Research, The General Engineering Co. Ltd., Toronto, Canada, and M. C. D. Hobbs, General Superintendent, Western Canada Steel Co., Vancouver, B. C., Canada.

"Hot Extrusion of Carbon Steel Solid Sections," by Joseph K. Seyler, Superintendent, Hazelwood Cold Finishing Dept., Jones and Laughlin Steel Corp., Pittsburgh, Pa.

"Switchgear and Rectifiers," by Steven Muryn, Electrical Engineer, Indiana Harbor Works, Youngstown Sheet and Tube Co., East Chicago, Ind., Frank Nolan, Switchgear Engineer, and A. D. Millikin, Rectifier Engineer, Allis-Chalmers Manufacturing Co., Milwaukee, Wisc.

"Selection of a Lubricant for Cold Drawing," —
Part I **"Coarse Steel Wire,"** by Bruce W. Siemon, Standard Industrial Compounds Co., Chicago, Ill.
Part II **"Fine Steel Wire,"** by W. B. Bauzenberger, Sales Manager, Apex Alkali Products Co., Philadelphia, Pa.

"The Use of the Modern Assel Mill in the Production of Seamless Steel Tubing," by Charles E. Snee, General Foreman, Assel Mill, Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio.

"Modernization of an Industrial Plant Power Distribution System," by A. C. Stoever, Superintendent of Utilities, Granite City Steel Co., Granite City, Ill.

"Rolling of Thin Strip — Part II," by M. D. Stone, Manager Research and Development, United Engineering and Foundry Co., Pittsburgh, Pa.

"Integrated Electro-Mechanical Press Puller Drive System Improves Extrusion Quality," by R. C. Suttle, Application Engineer, Metals Div., Reliance Electric and Engineering Co., Cleveland, Ohio.

"Electric Drive System for Blooming and Slabbing Mills," by C. C. Thomas, Steel Mill Engineering System, Application Engineering Section, General Electric Co., Schenectady, N. Y.

"Increasing Capacity of Ladle Cranes," by Eugene Whitaker, Mechanical Engineer, Granite City Steel Co., Granite City, Ill.

"Increased Steel Production From Desiliconized Hot Metal," by E. C. Wright, Head, Department of Metallurgical Engineering, University of Alabama, University, Ala.

"Contributions to Arc Furnace Operations," by L. A. Wynd, Superintendent Electrical Dept., Republic Steel Corp., Chicago, Ill.

INSPECTION TRIP

On Thursday afternoon, September 29, there will be an inspection trip to the Indiana Harbor Works of the Youngstown Sheet and Tube Co. Buses will leave from the Hotel Sherman.

HOTEL ACCOMMODATIONS

Hotel reservations should be made direct to the hotel of your choice giving time of arrival and type of accommodations which are desired. Reservations should state that they are for the AISE Convention. If they are unable to take care of you, they will forward your request to the Chicago Convention Bureau, who will place you elsewhere.

SOCIAL FUNCTIONS

Social functions will take place at the Hotel Sherman, headquarters for the convention.

MISCELLANEOUS

Final program giving detailed titles and authors' names will be mailed within the next month.

By HOWARD E. DEGLER
Technical Director
The Marley Co.
Kansas City, Mo.

COOLING TOWERS for Steel Plants

—Why, When, Where and How—

. . . . from 40,000 to 80,000 gallons of water are required to produce a ton of finished steel . . . . the ever increasing demand for the available water necessitates that every possible means be used to conserve its supply . . . . cooling towers are one means for reducing water consumption, as only a small percentage is lost by evaporation and drifting . . . . with reuse of water, water treatment practices otherwise uneconomical become practical . . . .

▲ WATER is America's number one natural resource; however, the supply is exhaustible, as is coal, oil, or timber. It is as essential to industrial life as it is to animal and plant life. Paradoxically, industry requires chemically purer water than does biologic man. Most industries need increasing amounts of water and could benefit from better quality cooling water. For instance, in the steel or power industry, the use of raw river water "once through a condenser" requires frequent cleaning of the tubes, and the use of costly divided water-box condensers. Re-use of this circulating water by recurrent cooling in a cooling tower would provide these advantages—minimize cleaning of tubes, require smaller cooling equipment, as well as conserve the water supply and furnish a ready means for properly treating the water.

WATER REQUIREMENTS

In all parts of the country there is a growing recognition that water conservation daily assumes greater proportions. More water is required as our population grows and industry expands. Large industrial water users are power plants, manufacturers of iron and steel, petroleum products, atomic energy, rubber, chemicals, paper and wood pulp, textiles, and many others. Requirements are frequently in excess of 300 pounds of water per pound of finished product; see Table I for typical examples. Stream pollution by some industries constitutes another tremendous problem, and some form of waste treatment need be considered for much of the total circulated industrial water supply.

TABLE I

Water Use in Typical Industries

Product	Lb of water per lb of product
Aluminum	500
Ammonium	700
Butadiene	1200
Gun powder	400
Hydrogen	2500
Lactose	800
Linen	700
Oil refining	500
Paper	200
Rayon	800
Rubber (synthetic GR-S)	2500
Soda pulp	300
Steel	250*
Textiles	350
Wool	500

*Double or more if plant has unlimited water supply.

A paper, "Water Supply for Steel Plants," was presented at the 1953 AISE convention by Ross Nebolsine of Hydrotechnic Corp. His paper points out the important role of water supply and requirements in the steel industry. It includes a description of the water demands of integrated steel plants, the principal features of the water systems used, and the methods for improved utilization of available supplies, the quantity and quality of water required, and typical steel plant water distribution systems. Table II is from that paper.

The water distribution in a modern steel plant comprises at least six distant piping systems, as indicated

TABLE II

Approximate Water Requirements of a Typical Modern Steel Plant that Re-Uses Its Cooling Water

Major departments of the steel plant	Gal of water per ton of finished steel	Per cent of Total
1. Blast furnace (includes turbo-blowers, furnace cooling and gas washers)	10,000	25
2. Open hearth area	5,000	12½
3. Coke plant	5,000	12½
4. Hot mills and related processes	10,000	25
5. Finishing mills and related processes	8,000	20
6. Sanitary, boiler, make-up, etc.	2,000	5
Totals	40,000*	100
7. Electric power, steam condenser	10,000+ to 50,000+	

*Double or more if plant has unlimited water supply.

by the items in Table II. At plants where water conservation must be practiced, the number of systems may be greater to provide flexibility in the repeated use or re-use of water after cooling or treatment. An example of an integrated water-flow diagram and distribution system is shown in Figure 1. More detailed water-flow diagrams have been published in the July 10 and 17, 1952 issues of Engineering News Record for U. S. Steel's Fairless Works, Morrisville, Pa.

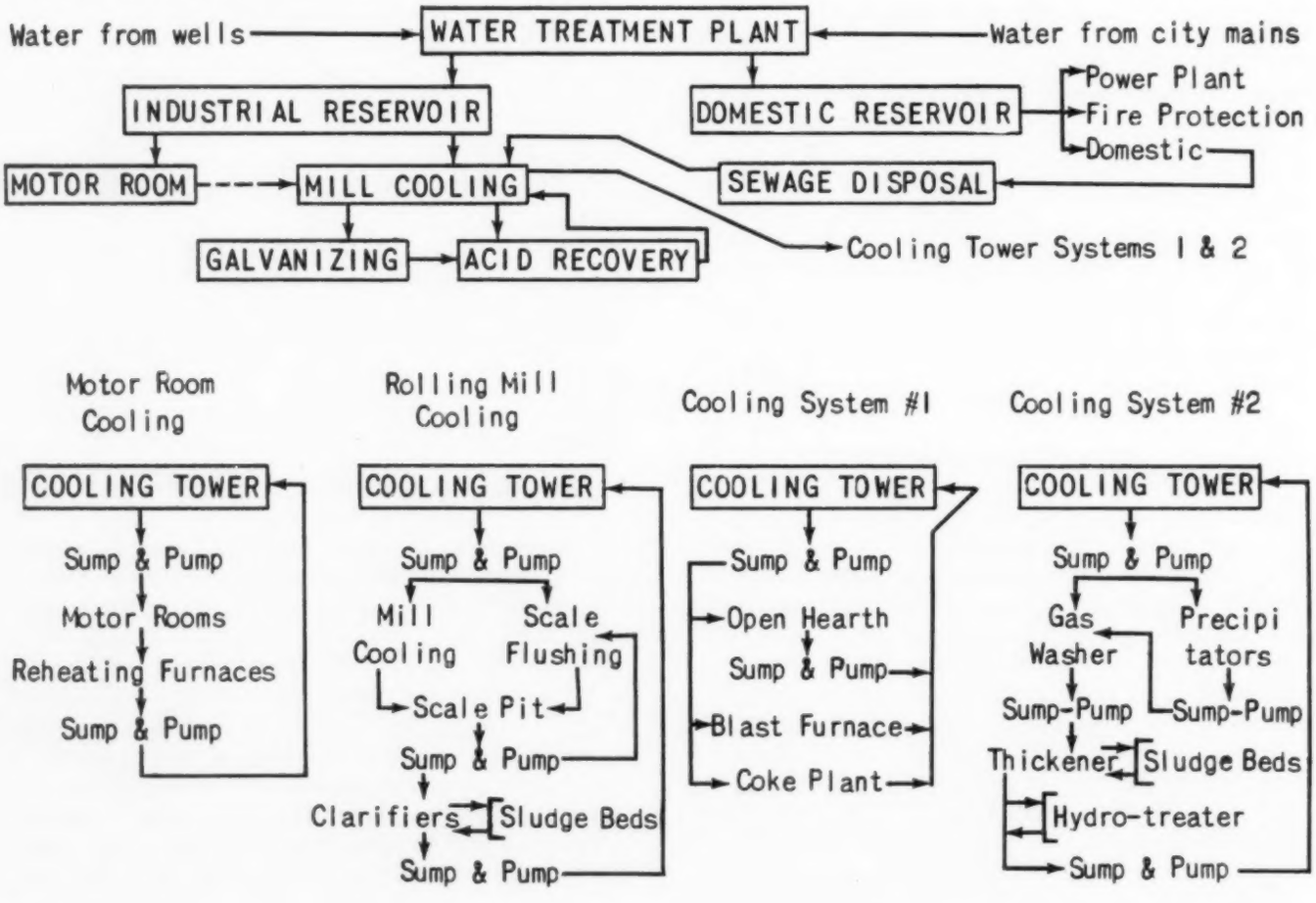
STEEL PLANT WATER SUPPLY

Most of the water requirements in a steel plant are for general cooling purposes. If the source of supply is limited, the water could be recirculated through cooling towers, spray ponds, or lakes, and only the make-up water would be treated. If salt or brackish water were used, special materials would be used for the piping and the heat exchange equipment to minimize corrosion.

Many steel plants are located on the banks of rivers, lakes, or artificial ponds. The removal and dissipation of the heat from the various processes and the generation of power may be accomplished by taking in the cooling water at considerable distance from the discharge, thus preventing mixing of the heated discharge with the inlet water. However, the use of river or lake water for process cooling has the following disadvantages: plant may be far removed from source of raw materials, limitations for plant expansion, local restrictions on use of water (pollution, high temperature, or damage to fish), costly intake structures with screens and sediment basins, flood or drouth conditions, the vagaries of most rivers, upstream pollution, scale-forming constituents, debris, sand, and algee, formation of troublesome ice, treatment of plant effluent, and others.

Treatment of huge quantities of river supply water is not practicable for once-through cooling systems, whereas recirculation with interposed cooling towers

Figure 1 — Flow diagrams show water distribution at the Kaiser Fontana Steel Plant; note the use of cooling towers and other water re-use features.



makes treatment and re-use economical. It avoids all of the above disadvantages of expensive river intakes, stream pollution, high and low water level, refuse, etc.

Among the largest users of water in a steel plant are the blast furnaces and the rolling mills. The cooling water for the furnaces and for gas washing frequently comes from the discharge of the condensers for steam driven turbogenerators and/or turboblowers. Water used by a hot rolling mill is used primarily for cooling the reheating furnaces and rolls, and for sprays that remove and transport the mill scale. This water should contain very little suspended matter and be of good quality for use by the high pressure sprays and the hydraulic systems, as sediment would foul the nozzles or score the cylinders of high pressure pumps.

The doors and frame of the open hearth furnace are water cooled. A large byproduct coke plant recirculates cooling water from the primary condenser and final coolers. The cooling water supplied to the cold rolling mills, electrolytic tinning, galvanizing lines, and other finishing and recovery operations require relatively clear and pure water.

STEEL PLANTS USING WATER CONSERVATION

The following steel plants are typical examples of water conservation where the source of supply is limited:

1. At the Kaiser Fontana plant, wells with limited capacity constitute the main source of water supply. The total circulation is 30 to 40 times as large as the "make-up" supply. This must be accompanied by the successive treatment of wastes and passage of the water through cooling towers. The flow diagrams in Figure 1 show how this is done.
2. At Geneva, Utah, an entirely different method is used. The discharge of all clear cooling water is recirculated through a large lake where the water is cooled by natural evaporation to a temperature of 65 F after traveling two miles between the points of outfall and intake. The "make-up" is about 10 per cent of the volume circulated and comes from wells, springs, and small streams. Most of this water, in the form of blow-down, is discharged and used for irrigation.
3. At the Bethlehem Sparrows Point plant, the water problem was met by developing supplementary sources of supply when it was found necessary to reduce abstraction from fresh water wells. And additional supply from the Baltimore water system or other sources was not available. For these reasons, brackish water from Chesapeake Bay is used extensively for many cooling purposes. However, it is unsuitable for the cooling of rolls and for sprays. For these applications, a project based on utilizing reclaimed Baltimore sewage was successfully developed.
4. Another form of "forced" economy in the use of water is practiced along several rivers. Steel plants along the Ohio, Mahoning, and Monongahela Rivers successively utilize the discharges from other upstream plants. In the process, the water (at least in part) has undergone occasional treatment. At Youngstown, the entire Mahoning River is repeatedly passed through the steel plant piping networks. As a result the summer temperature of the river frequently exceeds 100 F. The use of cooling towers would reduce this temperature to 85 F, reduce the water recirculation rates, and undoubtedly improve operating procedures.

TYPICAL STEEL PLANTS USING COOLING TOWERS

The Kaiser Fontana, Calif. plant, located in a semi-arid region, recirculates (Figure 1) cooling water and re-uses effluent water from the sanitary and industrial waste treatment units. This highly integrated water distribution network is necessary because of the limited raw water supply and the necessity of completely treating the plant's liquid wastes in order to avoid complaints. All mill cooling water passes through clarifiers before returning to the cooling towers.

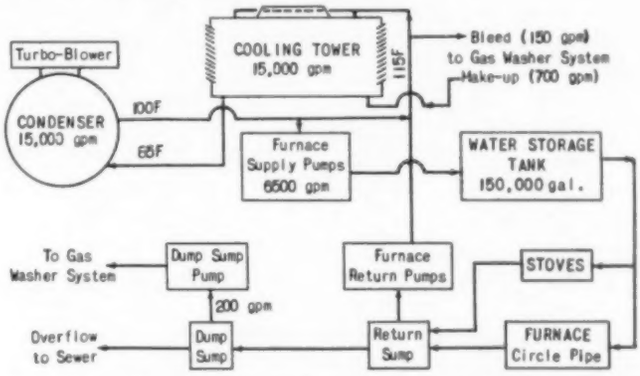


Figure 2 — Typical blast furnace re-circulating cooling water system is shown by diagram.

Water thrift is also practiced by Armco at Middletown, Ohio. The water flow in the blast-furnace cooling circuit is shown by Figure 2. Similar cooling circuits are employed for other subdivisions at this plant as follows:

Gas washer cooling water system includes a 5000-gpm cooling tower, gas washer, thickener, gas precipitators, sludge ponds, occasional sumps and pumps, similar to cooling tower system No. 2 in Figure 1.

Byproduct recovery cooling water system in the coke plant includes a 5200-gpm cooling tower to serve the tar plant, sulphate plant, oil recovery plant, gas purification plant, circulating liquid coolers, and other units.

Open hearth furnace cooling requires a number of cooling towers to serve the water-jacketed oil burners, doors and walls. A 225-ton furnace requires about 2500 gpm water; each heat requires about 10 hours.

Electric furnace cooling is required for the head (or roof), electrode holder, and furnace doors. A 1000-gpm cooling tower serves two electric furnaces, each with a capacity of 100 tons.

Slab heating furnace is cooled with a 3600-gpm cooling tower.

Rolling mill cooling with cooling tower water is outlined in the second unit of the flow diagram of Figure 1. Note the scale flushing, scale pit, clarifiers and sludge beds that are used to assure the return of clean water

to the cooling tower. One of these mills uses 6000-gpm water at 85 F and returns it to the tower at 120 F (for a 78 F wet bulb).

WATER CONSERVATION BY RE-USE

Conservation of water resources can be accomplished either through re-use of the water or elimination of wastage. Methods of conserving water through leak correction and economical usage will not be discussed in this paper. Attention will be centered upon ways to effect water thrift through re-use practices. Re-use methods are instituted in steel plants for one or more of the following reasons: (1) Limited water supply. (2) Economy, use of raw water always entails expense of procurement, fouling of equipment, and generally an additional disposal cost. (3) Recovery, valuable heat and materials may be lost in discarded process water.

Water, by having its waste-heat load transferred to the atmsophere in various types of cooling equipment, can be reused in a recurrent heat cycle and thus be conserved. Heat can be transferred from water to the air

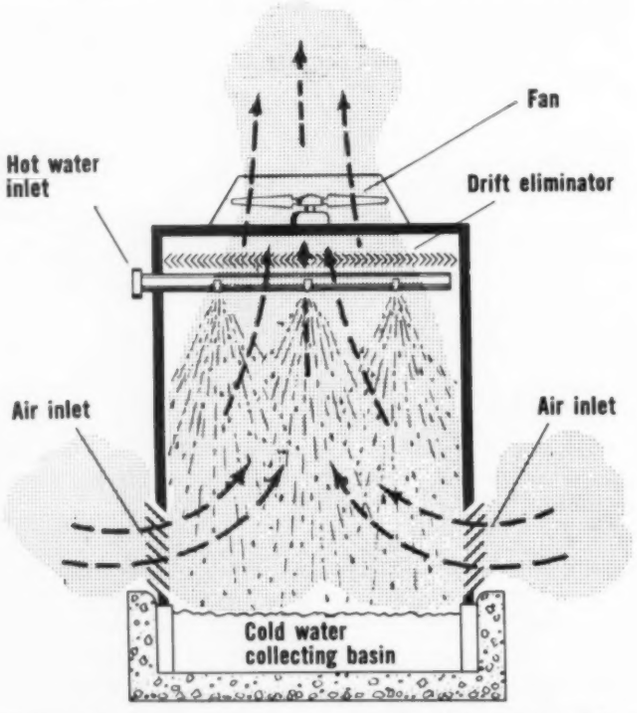


Figure 3 — Basic elements of a spray-filled counterflow water-cooling tower are shown.

indirectly (non-contact) as is done with an automobile radiator, or *directly* as is done with evaporative-cooling equipment such as cooling towers (see Figure 3) and spray ponds.

HOW COOLING TOWERS WORK

A water-cooling tower is an enclosed structure for the evaporative cooling of water by contact with moving air, see Figures 3 and 4. When water is cooled by this evaporation process, approximately 1000 Btu are transferred to the air for each lb of water evaporated. The heat contained in the water vapor thus produced is known as the latent heat of vaporization. Air, absorbing heat from water in this manner, is capable of cooling water to a temperature that approaches the wet-bulb temperature of the atmosphere.

In a water-cooling tower, as the water falls over the redwood splash bars from level to level (Figure 4), it splashes into fine droplets and spreads out over the redwood fill in thin films. This provides a large water-air contact area to the moving air. The rate of heat transfer, hence the water-cooling effect, will be accelerated by: increased air velocity, added water breakup, and lower humidity (wet-bulb) of the air for a given size tower.

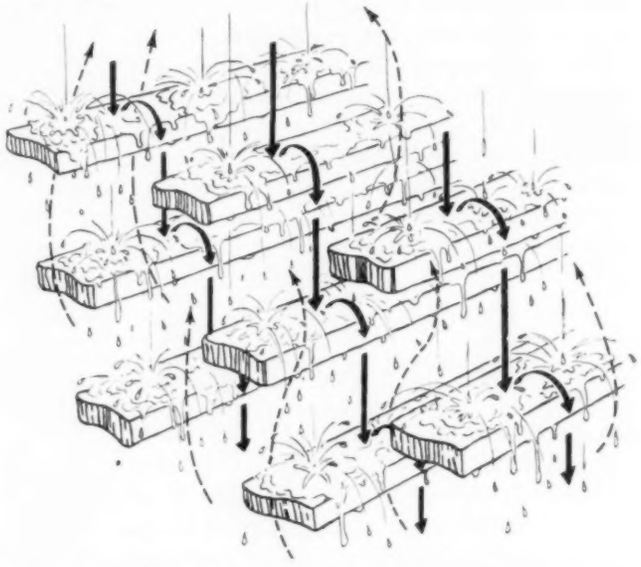


Figure 4 — Wood fill in towers provide more cooling surface and water breakup.

The type of cooling equipment used affects to a considerable extent the operating temperature of the water to be cooled. Spray ponds and natural-draft towers depend upon prevailing winds for cooling the water, hence these units must be designed, built, and selected for low wind velocity conditions. Such equipment cannot continuously maintain the desired cold-water temperature (or a close approach to the wet-bulb air temperature), hence mechanical-draft equipment must be employed to produce the required air movement and continuously obtain low cold-water operating temperatures.

Progress of the cooling tower industry is apparent when it is realized that for a definite need, a modern water-cooling unit requires only 1 sq ft of ground area as compared to 50 sq ft for the spray pond and about 1000 sq ft for a natural cooling lake or pond. The demand for a more compact design, better construction, lower cost, larger capacity, greater flexibility of operation, independence of atmospheric uncertainties, and improved all-around performance has resulted in the modern induced-draft tower.

WET-BULB, RANGE, APPROACH TEMPERATURES

Lowest temperature to which water may be cooled in cooling towers is the temperature of adiabatic saturation—the wet-bulb temperature of the ambient air.

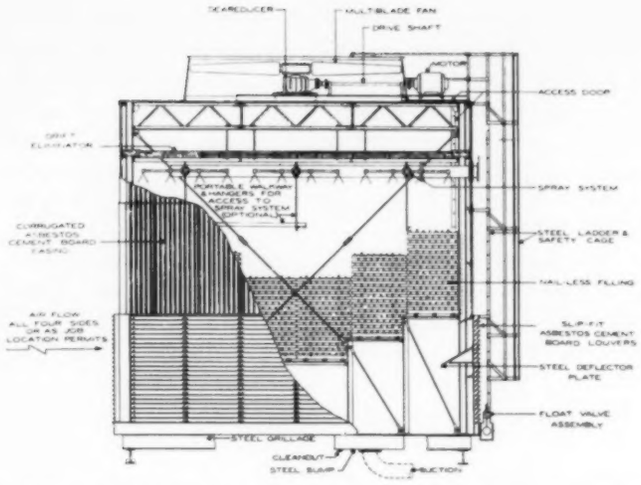


Figure 5 — Section of typical induced-draft cooling tower shows rugged simplified mechanical equipment on conventional industrial type tower of medium capacity, 1000-5000 gpm.

Tower performance is measured in terms of "approach" of the cold-water temperature to the air wet-bulb temperature when cooling the water through some desired "range." For a definite heat load, the approach to be obtained would depend largely upon the geographical location (design wet-bulb), the cooling range, and the type of water-cooling equipment. A close approach requires a larger and more expensive tower than a long approach. For example, the cost of a tower for a 5 F approach would be 1½ to 2 times that of a unit for a 10 F approach with a given heat load.

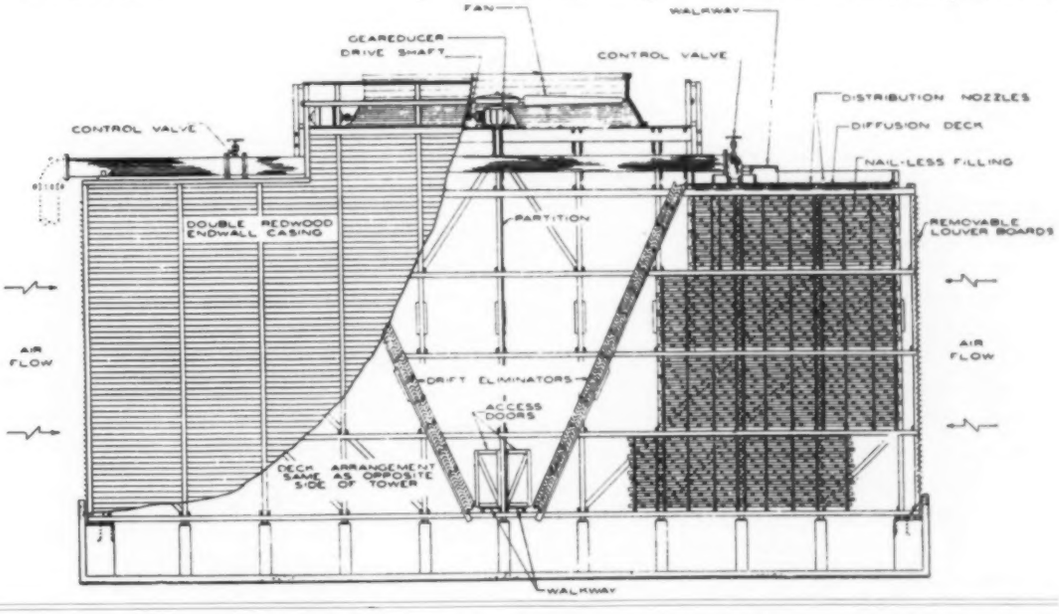


Figure 6—Induced-draft cross-flow (double-flow) cooling tower of large capacity, 5000-100,000 gpm. Note open top water distribution system, full height louver opening and large drift-eliminator area.

The wet-bulb temperature to be specified should be selected from summer weather data for the proposed tower location. Consult local U. S. Weather Bureau Statistics or "Engineering Manual for Industrial Cooling Towers." The wet-bulb temperature selected is generally a temperature not exceeded more than 5 to 10 per cent of the total hours from June to September of a normal summer. The hours that the wet-bulb temperature exceeds the 5 per cent value are not consecutive hours but occur in periods of short duration. The fly wheel action of the cooling cycle is usually sufficient to carry over such a condition. Generally, production may be retarded for a short time without experiencing a loss that would dictate additional expenditure to meet the extreme temperature conditions for perfect results.

MECHANICAL DRAFT TOWERS

Most present day industrial towers are of the induced draft type, as shown in Figures 5 and 6. These towers consist usually of a vertical shell constructed of redwood, metal, or asbestos-cement siding. Hot water is distributed near the top uniformly over the area and falls to a cold-water collecting basin. This water passes through the air which is being circulated in the tower from bottom to top by fans which are an integral part of the tower. Induced draft towers may be subdivided into two distinct types—counterflow and crossflow.

In wood-filled towers, splash bars of lumber are laid horizontally across the space and on close centers, both horizontally and vertically, thus introducing some resistance to air flow. The water is distributed over the top layer by means of spray nozzles, troughs, or splash heads, and drops from piece to piece of the wood filling as it progresses downward. As the air moves upward and/or across the wood filling, the latter presents a large wetted surface, repeatedly breaking up the falling drops of water, and continuously providing new drop surfaces whose integrated areas are several times that of the splash bar area.

The efficiency of a mechanical draft tower is improved by increasing the amount of filling, height, area, or air quantity. Air velocities through mechanical draft towers vary from 300 to 450 fpm over the gross area of the structure, with peripheral fan-blade tip velocities averaging 11,000 fpm. Right-angle gear speed reduction units are interposed between the electric motor drive (1800 rpm) and the fan.

The *counterflow* (conventional) type of induced draft tower has the fan located at the top, Figure 5, to provide vertical air movement across the filling and discharge it upward at a high velocity. Before dis-

charging to the open atmosphere, the moisture-laden exhaust air passes through a drift eliminator to remove entrained unevaporated water that might be carried from the tower by the air movement.

Disadvantages of counterflow towers (compared to crossflow design) include: (1) Increased fan horsepower required because restricted louver area creates high velocity of inlet air. (2) Higher static pressure loss and increased fan horsepower to overcome resistance to upward air travel against the falling water. (3) Very little air movement near walls and bottom center of tower, see Figure 1. (4) Restricted air flow through limited eliminator area, especially with flume type hot-water distribution. (5) High pump head because of height of tower and nozzle pressure, wood fill placed high in tower. (6) Limited water-loading capacity, generally less than 8 gpm per sq ft. (7) Inaccessible hot-water distribution system for ready maintenance.

The *crossflow* (also called double-flow) tower, Figure 6, reflects the ultimate in modern design of induced draft cooling towers, and eliminates or minimizes many of the disadvantages of counterflow towers. Outstanding features are horizontal air flow as water falls across the air stream, compact design, large capacity, improved performance, greater structural stability, flexible operation, low pumping head, low static pressure drop on airside, open hot-water distribution basin, uniform distribution of air and water throughout tower, lower cost, and less maintenance combined with accessibility.

The distinctive crossflow tower design employs large air inlet areas and horizontal air flow with one or more fans at the top; in this double-flow tower one fan draws air through two cells paired to a suction chamber which is partitioned midway beneath the fan fitted with drift eliminators that turn air upward toward the fan outlet.

Air flow in crossflow towers is even, horizontal, and of uniform velocity for the full travel through the cooling chamber, equalized over the chamber's entire breadth and height by the unique arrangement of full height air inlet louvers and drift eliminator; the latter serves as a pressure-equalizing valve to assure equal air distribution throughout the tower volume. Greater air quantities with least draft loss are possible since the air movement is unobstructed either by internal systems for hot-water distribution or by wood splash bars placed broadside to the air's path.

Water flow is likewise improved in the crossflow design. Uniform hot-water distribution is obtained through independently regulated flow valves at each tower cell and evenly spaced porcelain nozzles (¾ to 1 in. diam) located in the floor of the open overhead basin, from which the water flows by gravity to a diffusion deck located directly beneath the nozzles, as indicated in Figure 6. This uniformity of water flow is maintained on down through the wood filling to the cold water basin.

TOWER DESIGN FEATURES AND SPECIFICATIONS

Because of the many variables in water-cooling tower calculations and performance, it is difficult to provide simple handbook equations and tables whereby an engineer can readily select the type and size of unit for definite water-cooling requirements. Each cooling tower manufacturer has his distinctive method of sizing a tower, based largely upon research and performance. The selection of industrial cooling equipment for any application must ultimately depend upon overall considerations from reliable design and performance data.

The correct type and size of cooling equipment for a given service cannot be determined intelligently without considering the characteristics of the various types, together with the many correlated requirement factors. Very few installations are exactly alike in details and requirements. Hence conditions affecting performance and operation of cooling equipment vary widely because of the many diversified applications and widespread geographical locations.

The choice and use of the proper cooling tower depends primarily upon the heat load and type of service. Also upon the desired cooling performance, mechanical and physical limitations of the plant served, effect of the water circulated upon the heat transfer rate, required range and approach, and type of cooling tower desired.

The normal rating of a cooling tower is defined as the gallons per minute of water cooled through a given temperature range for a specified approach to the design wet-bulb temperature of the air. Many correlated factors, however, enter into the ultimate selection of the type and size of cooling tower.

The time-honored and practical method of writing specifications and requesting competitive bids, with complete statements of guaranteed performance, is the best procedure to obtain accurate and complete cost data for the selection of water-cooling equipment. The question will inevitably arise as to whether or not the lowest of competitive bids (on perhaps the poorest equipment) should be accepted, or whether a better quality should be selected at a higher price.

Some of the features to be considered in the preparation of cooling tower specifications include: kind of lumber and hardware, framework, timber connectors, hot-water distribution system, casing and partitions, wood filling and eliminators, mechanical equipment (fans, speed reduction gear, drive shaft, and motors), cold water basin, access and safety, accessories such as piping, valves, nozzles, stairway, ladder, anchor bolts, and foundation, also sound intensity, performance at varying conditions of operation, tests, and evaluation of costs (owning and operating).

Tests to demonstrate the performance of the installed cooling tower should be made in accordance with the current Cooling Tower Institute Test Procedure TSC-101 or the current ASME "Power Test Code for Atmospheric Water Cooling Equipment."

COOLING TOWER COSTS

Table III shows characteristics and costs for two representative sizes of cooling towers for the years 1925, 1932, 1941, 1950, and 1954. This reveals more than a quarter century of design improvements. Careful study reveals that great reductions have been made

TABLE III

Characteristics and Costs of Cooling Towers — 1925 to 1954

95 F Hot Water — 85 F Cold Water — 75 F Wet Bulb

Capacity	5000 Gpm					20,000 Gpm				
Years	1925	1932	1941	1950	1954	1925	1932	1941	1950	1954
Base, ft	22 x 96	30 x 72	30 x 80	36 x 48	24 x 50	36 x 220	26 x 240	40 x 240	60 x 60	42 x 72
Height, ft	40	36	26	20	22	40	36	26	26	36
Area, sq ft	2112	2160	2400	1730	1200	8420	8640	9600	3600	3024
Fans, number	6	6	4	2	1	22	24	10	2	3
Size, diam ft	11	11	13	14	18	12	11	16	22	20
Bhp, each	28.4	19.2	24	20	50	30	19.2	38.4	70	58
Bhp, total	170.4	115	96	40	50	660	461	384	140	174
Dry weight, lb	280,000	260,000	240,000	110,000	90,000	960,000	940,000	900,000	290,000	320,000
Pump head, ft	27	27	20	14	21	28	28	20	26	37½
Total cost	$22,000	$20,000	$19,000	$18,500	$16,000	$78,000	$ 71,000	$67,000	$62,000	$52,000*

*1943-45 prices were 70 per cent of this amount.

in the number and horsepower of fans, space requirements, weight of units, and installed cost during this 30-year period despite the recent inflationary period. It should be noted that the 1943-45 costs were about two-thirds of that for 1954.

The above cooling tower progress (Table III) is further evidenced by improved performance, flexibility of application, better appearance, negligible drift loss, and simpler structure, with resultant lower maintenance and greater safety. The increased costs of labor and materials for today's cooling towers have been offset by better engineering as reflected by continued improvement in the design and developing every opportunity for reductions in the cost of production and operation.

OPERATION AND MAINTENANCE

Pages of recommendations could be written on the starting-up, operating, maintaining and shutting down of cooling towers in order to obtain optimum results under varying load requirements and changing weather conditions. The life of any piece of cooling equipment is directly dependent upon its built-in features, type of service, severity of operation, general care and maintenance, and climatic environment.

The continued utility of all cooling equipment depends primarily upon the maintenance of the mechanical equipment; next in importance is cleanliness of the unit; water treatment (with necessary blow-down) is a must for most systems using cooling towers.

Well maintained units would probably give good performance for years whereas a neglected unit might decrease its cooling efficiency as much as ½ per cent per month. It should be emphasized that there are many cooling tower installations which are 15 to 20 years old, and still giving practically as good service as the day they went into operation.

Unless a good maintenance schedule is followed, decrease of cooling performance would result. Economizing on cost of labor for maintenance would result in increased expense for replacement parts and periodic repair costs. There may be a few installations where this approach might be applicable with soft water, and where there is no dust or sand in the air. However, any equipment which has motors, fans, gears, pumps, etc., is of necessity susceptible to failure unless regularly inspected, lubricated, and maintained.

Water treatment—Treatment of cooling water includes: prevention of corrosion and scale formation on heat-exchanger equipment; prevention and control of algae; and control of deterioration of cooling tower lumber. It is desirable to maintain the pH of the circulating water between 6½ and 7½

The amount of make-up water required depends upon evaporation loss, drift loss, and blow-down. Evaporation losses average 0.75 per cent of the water circulated for each 10 F range. Drift loss is the water carried away by the air current in the form of droplets or mist. This loss approximates one-tenth of one per cent of the water circulated.

The amount of blow-down water required depends upon the hardness of the circulating water, the type of water softener or inhibitor used, and the amount of drift loss. Blow-down is normally controlled to maintain the concentration of dissolved and scale-forming solids below the point where the formation of scale would occur or would be caused by corrosion. The total amount of solids introduced by the make-up water equals the total removed by the blow-down, hence the ratio of make-up to blow-down indicates the number of concentrations in the system. For best results, a competent water chemist should be consulted.

Winter operation—Water temperatures below 60 F are not required or desirable for some industrial processes since the equipment was designed for higher cooling temperatures and a constant heat load; also, operating hazards are increased considerably with these colder water temperatures. Cooling towers operated in cold weather are subject to ice formation at the air inlets; small amounts of water are likely to freeze on the inlet louvers and the nearby wood splash bars. Ice

starts to form on the lower section of louvers and progresses upwards; this accumulation of ice restricts the inlet area and reduces the air flow, thus increasing the temperature of the water being circulated through the tower.

The main mass of the tower circulating water is rarely cooled to a temperature that even approaches freezing; in fact, the cold water temperature will seldom be lower than 60 F, except with towers used for specific operating conditions. For this reason, ice will form only on parts of the tower that are lightly wetted by fine drops which splash toward the entering air stream.

To prevent icing during cold weather operation, one or more of the following procedures are recommended for induced draft towers: (a) shut down or reduce speed of fans, but do not shut off water; (b) cover upper portion of louvered area with canvas; and/or (c) shut off some of the cells.

If ice should form on the louvers and filling, one of the following methods of removal could be used: (a) reversing (for a limited time) the rotation of the motor driving the fan and thus blowing the warm air backwards and out through the louvers; (b) shut down some fans temporarily but do not shut off water; and/or (c) cover upper portion of louvered area with canvas.

Mechanical maintenance—A regular daily inspection schedule is recommended to determine whether the cooling equipment is operating properly. The cooling unit in operation becomes but part of a system made up of several other auxiliaries. Therefore, it may be blamed for unsatisfactory performance which is only a symptom of failure in another part of the system.

SUMMARY

Getting enough cooling water of the right temperature and quality has become one of the difficult jobs for many steel plants. Elaborate engineering techniques are employed today to develop and conserve adequate supplies of industrial cooling water. As a result, water costs are increasing.

Satisfying the water requirements of the steel industry, while an enormous undertaking, is only part of the overall water supply problem. The most effective solution of our national water problem can come only through the close co-operation and co-ordinated effort of all interested groups, most certainly including the steel industry, working toward the achievement of a common objective—ample water for all America.

Once through use of water is wasteful. The same water has multiple uses. Evaporation in cooling processes only slightly reduces the water supply. Water can be purified; it can be cooled in cooling towers and reused. The increased use and wider application of cooling towers in the steel industry is a means for conserving water supplies and improving plant economy.

The application, performance, operating features, and ease of maintenance of a proposed cooling tower installation should be evaluated to assure the most economical selection. As the need for water conservation increases, the manufacturers of industrial cooling towers have been accumulating a great reservoir of experience by continuously making more economical units and more highly specialized applications.

DISCUSSION

PRESENTED BY

HARRY I. RIEGEL, Superintendent of Utilities, Kaiser Steel Corp., Fontana, Calif.

JOSEPH A. MARLAND, Vice President and Manager—Sales and Service, W. A. Jones Foundry and Machine Co., Chicago, Ill.

HOWARD E. DEGLER, Technical Director, The Marley Co., Kansas City, Mo.

Harry I. Riegel: We are going to hear more as time passes on the conservation of water. Water is one of our necessary, but limited, resources. Wasteful practices of the past must be reduced because our requirements are increasing with our population growth and the associated requirements of these people for industrial commodities. The use of cooling towers with the use of other practices, including chemical treatment, offers a real approach to the problem.

Mr. Degler has shown a diagram (Figure 1) of the water system used at Kaiser Steel Corp. plant at Fontana. He naturally did not know the problems that were encountered in making this system work. Our problems were many.

We found that it is impossible to explain to management that a production unit cannot operate or its yield is reduced because the wind did not blow, and if it did blow, it was in the wrong direction. We started with natural draft towers and now will not consider anything but forced or induced draft towers. Please remember that it is going to be equally hard to explain to management that the mill must shut down because it did not rain this year.

We have also found that the basin underneath a tower is very important. The cooling towers are excellent air washers, and the dirt removed is usually deposited in the base of the towers. The same can be said for suspended solids in the water as the result of the process, the makeup water and, or the chemical treatment. By having a fairly large volume in the basin, good precipitation of dirt is secured. Having accumulated the dirt, some quick and economical way must be provided to remove the dirt during normal low tower requirement periods. On our later towers, we have them designed so that sections can be isolated and proper drains are in each section. The base is cleaned with a fire hose in two to four hours using two men. Our older towers were not equipped with proper drains, and this condition plagues us to this day. We find that manual cleaning is very expensive and requires too much tower outage.

Cooling towers cost money to install and money to operate. Mr. Degler's paper has the statement "Double or more if plant has unlimited water supply," under Table II. This statement is very true. When you go through the transition from one type of operation to the other, you can expect a great deal of resistance. The mill will not operate unless it is flooded because the

operators have never seen a mill otherwise. We went through the transition, and I warn you, be prepared for a rough time. Many conservation practices must be instituted; otherwise, you will be called upon to install cooling tower capacity for the 80,000 gallons per ton of finished steel instead of the 40,000 gallons mentioned in the table.

We have been operating for over 12 years with all of the original towers still in use. The maintenance has been nominal for the fans with speed reducers driven by drive shafts. The maintenance on the wood portions has been practically nil. It is good news that the cooling tower cost per unit of cooling has reduced.

Joseph A. Marland: One of the diagrams shows an illustration of a motor connected to the speed reducer with a full-floating shaft and gear-type self-alining couplings. Could Mr. Degler point out the relative advantages or disadvantages of such a floating shaft connection as compared with the motor integrally bolted to the speed reducer housing or with the motor closely coupled to the speed reducer unit?

Howard E. Degler: That is a very interesting question. We have gone through this method of gear-motor or unit drive, the motor direct-connected with the fan. It has definite advantages, but has considerable practical disadvantages of mounting and continuously operating in the saturated humid atmosphere, as well as higher cost. During the past five years one of the large cooling tower manufacturers did use this so-called unit drive; I believe they have discontinued it recently because of the structural and operational difficulties.

We still hear about it occasionally, because there are some folks who are intrigued by this very simple arrangement which, however, does not work out in actual operation and maintenance. We use the full-floating drive shaft you mention, where a special flexible coupling is at the motor and gear end of the shaft.

We use spiral bevel gears, 50 horsepower or less, in the speed reducer; for higher horsepower hypoid gears are used. The problem of speed reduction (motor to fan) is similar to the rear-end transmission in your automobile.

STUDY OF PRODUCTIVITY OF CONVENTIONAL DWIGHT-LLOYD SINTERING MACHINE*

▲ IT has long been recognized that physical characteristics of the feed to the Dwight-Lloyd sintering strand are the most important factor in controlling the production rate and the quality of sinter. It has been established by various investigators that for a given set of raw materials the production rate is governed by the amount and the velocity of the air pulled through the sinter bed.

The results of the investigations demonstrate clearly that the production rate of sinter can be increased substantially by making proper changes in the equipment and the operational practices used at the conventional installation.

The essence of the changes required to attain this goal is to: (1) improve the permeability of the sinter feed, (2) increase the rated capacity of the air fans of the sintering machines, (3) provide satisfactory means of controlling the sintering process through proper instrumentation. The experimental results permit the following conclusions to be drawn in regard to the three main factors.

Improving Permeability of Sinter Feed—In order to realize the expected increase in the permeability of the feed, the following requirements must be fulfilled:

1. Uniformity of sizing and composition of the basic raw materials. Sizing of ore to minus ½-in. seems to be required. Even proportioning and intimate mixing of flue dust and ore passing through the screening station is necessary.
2. Control of the size and the amount of return fines entering the raw material cycle.
3. Control of the size and the amount of fuel. Use of minus 6-mesh or 8-mesh fuel allows the sintering zone to be sufficiently narrow, which was found to be beneficial to the sintering rate.
4. Control of the moisture content of the feed.
5. Inclusion of a pelletizing drum between the pugmill and charging stand of the sintering machine.
6. Use of additives in the pelletizing process. This is conditional and the feasibility of the use of additives must be determined for each specific feed.

The test results indicate that the proper use of these factors will assure not only high pre-ignition permeability but also high permeability during the entire sintering process.

Increase of Fan Capacity—The calculations show that the present capacity of the air fans is insufficient and should be increased to approximately 350 to 400 cfm per sq ft of grate area.

Control of Sintering Process—The investigation of the operational variables indicates that the control of the sintering process should be limited to two functional steps:

1. Control of the flow and the proportioning of the individual ingredients of the basic raw material feed (ore, flue dust, fuel, return and settling fines). This end of the control can be accomplished by installing weightometers in the proper positions and providing sufficient storage capacity for return fines and settling fines.
2. Control of the performance of the sintering machine and of the machine auxiliaries. This includes controlling the moving rate of the machine, temperatures of the exhaust gases and pressure drops in essential positions, and the volume of the air moving through the bed.

*From paper by M. O. Holowaty, H. A. Goldfein, and C. B. Sheets, chief of Raw Material Research, Research and Development Dept., Blast Furnace Engineer, and General Foreman, Sintering Plant, respectively, Inland Steel Co., East Chicago, Ind., presented at Blast Furnace, Coke Oven and Raw Materials Conference, Philadelphia, Pa., April 18, 1955.

American Iron and Steel Institute 63rd General Meeting

. . . . in reviewing problems of iron and steel production, leading operators of the steel industry at the general meeting of the American Iron and Steel Institute held in New York City on May 25 and 26, 1955, presented a number of interesting papers . . . . among the meetings were two technical sessions, one on operations and one on product development . . . . some of the papers from these sections of particular interest to steel plant operators and engineers are abstracted here . . . .

"PIONEERING IN NEW DEVELOPMENTS IN A SPECIALTY STEEL MILL"

by H. GEORGE DE YOUNG, Executive Vice President, Atlas Steels Limited, Welland, Ontario, Canada

▲ THIS paper is designed to be a factual report on the present satus of four very revolutionary developments which we at Atlas have included in an expansion program: (a) the continuous casting process, (b) the automatic scarfing machine for use on stainless steels, (c) the sendzimir hot planetary mill, and (d) the electrolytic salt descaling process integral with our annealing and pickling line.

At present the electrolytic salt descaling process is completely out of the development stage and in full commercial production. The other three developments we have proven to be commercially successful. We must yet become more proficient in their use and work some "bugs" out of engineering and operations before their economic success is fully realized.

CONTINUOUS CASTING

The continuous casting process resolves itself into the manipulation of a series of continually changing conditions to achieve a constant result. The tapping and ladle temperatures are key points in this operation and because they are variable we have a variable starting point. We found it necessary to conduct a series of experiments to learn how to control a number of variables.

At present there are certain limitations and disadvantages in the operation:

1. The knowledge is limited and hard won. Whenever a different composition or size is to be cast, all data must be collected through operations. Therefore, earlier savings are constantly being reinvested in experiments.
2. The size of the section is limited as yet, but this will quickly disappear, particularly for slabs.
3. Speeds and methods of cutting off the product limits production.
4. Until a shop is designed around the continuous casting machine, the melt shop scheduling is hard to adjust and delays result.
5. Higher temperatures and longer ladle times take their toll of ladle and furnace refractory life.
6. Some charging times in the melt shop will increase as the returned scrap to the melt shop decreases.

The continuous casting machine produces billets with a very satisfactory surface. From our operations to date we know that good surfaces can be obtained under a very comfortable range of operating conditions. Poor surfaces result from very slow pouring into the continuous casting mold, just as they are so produced on standard ingots.

One of the criticisms people most often have of continuous casting is the expected non-uniformity as far as chemical composition and segregation are concerned. From our work to date, it can definitely be reported that no unusual variations in chemistry have been detected. Samples taken at intervals throughout the pouring operation for chemical evaluation indicate that we have no problem with chemical variation from the beginning to the end of the cast.

The next phase of the quality evaluation necessarily deals with the general characteristics of internal quality as shown by deep acid etching and microscopic examination. In the early stages of developing this equipment, and during the time in which we were learning the mechanical operations, training personnel, and learning the operating factors for casting sound billets, most of the castings made were of unsuitable quality. A great deal of the material was rejected because of poor cast structure primarily due to a faulty center.

To control the as-cast quality we must know what the machine does and how its behavior is affected by changes in the operating conditions. For examples, Figure 1 summarizes the present knowledge concerning the heat removed by a slab mold. It illustrates that, as the casting speed is increased, the total heat removed by the mold per minute increases and yet the heat removed per pound of steel cast decreases. The implication is, of course, that the casting wall becomes thinner and/or hotter and more liable to rupture. Similar heat removal data have been gathered for the spray systems. The as-cast quality depends on and will

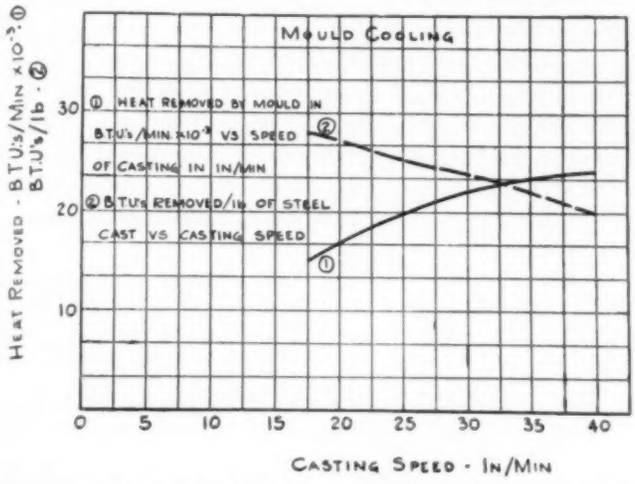


Figure 1 — Curves give data on heat removed by a slab mold.

change with the cooling conditions. It is clear, then, that for uniform quality the cooling industry should not change. The surest way to reach uniform cooling intensity is to establish constant casting speeds. This is difficult to achieve in practice. Yet it is necessary, since changes in casting speed must be accompanied by suitable changes in cooling water volumes to maintain fixed cooling conditions and quality.

We felt that at the earlier stages of perfection of the continuous casting operation it would be wise to put some reduction on the metal in the blooming mill and to condition before going to the finishing process. We can now definitely say that the elimination of the blooming mill entirely from the processing can develop in the future. Many experiments have been run with slabs from the continuous casting machine being rolled immediately to hot band with no prior conditioning. The results are very promising.

Regardless of whether the blooming mill stays in the picture, or if the pieces leave the continuous casting machine and go directly to a finishing mill, our plans called for a hi-head furnace to be ahead of the mill and after the continuous casting machine to retain the heat available in the slab or billet. This will also abolish length limitation imposed by the use of a soaking pit and allow for exploitation of certain inherent advantages in the continuous casting process.

The present status of the continuous casting machine shows commercial production of stainless slabs 5½ x 21½ in. of stainless 301, 302, 304 and 430 achieved. Part of each month is devoted to straight experimentation on the other molds and other compositions.

SCARFING

As steel progresses through the specialty steel mill there is an area where it has been very difficult to reduce manpower, and that is the chipping and grinding section. Almost all of the higher alloys such as high speed and stainless must have most of the skin ground from the billet before further processing. The scarfing machine, which has been in use in the steel industry for many years on low alloy and tonnage grades of steel, has been unavailable for stainless and heat-resisting alloys because of the higher temperatures required for scarfing and the difficulty in controlling this operation at the speeds required for uninterrupted rolling. Hand scarfing has not been satisfactory because of the resultant surface. There have been attacks made on this problem by the use of travelling grinders and billeteers.

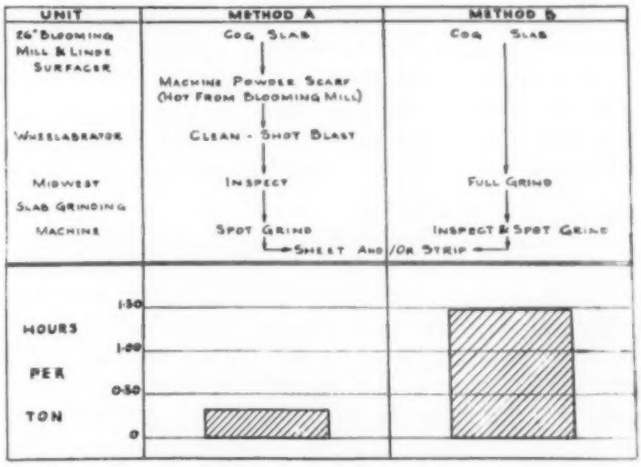
In 1953 a new type of head was installed on our scarfing machine for production runs. After more experimentation a successful slotted nozzle opening was arrived at with the powder nozzle having round tubes leading the powder against flat impingement discs of tungsten carbide.

Figure 2 shows that there is an indicated saving of about 1.2 man hours per ton. The metal removed by this process is about 3½ per cent.

One weakness of the scarfing process is that defects left in the slab are disguised and can only be revealed by shot blasting. Therefore we shot blast all slabs off the mill after scarfing and, if anything is discovered in them, we spot grind.

The difficulty we have experienced is that as the nozzles become worn the surface becomes rougher. Also, if there is a failure in the water seals, resulting in

Figure 2 — Two procedures for conditioning stainless slabs are prepared in this chart.



water getting on the slab, it causes the scarfing machine to miss sections. There has, at times, been evidence of incomplete powder and slag removal, particularly on 4-in. squares which have been rerolled on the mill following the blooming mill.

One of the discoveries we have made in the operation of this machine is that the slab is actually too clean when it is scarfed and a much more satisfactory surface can be produced if the slab has scale on it. We are now running a series of experiments in which a coating of some material is placed on the slab as it comes from the blooming mill to simulate a scale. The latest experiments were run during March using a mixture of iron powder and flux and another mixture of iron powder and graphite. These mixtures were more successful in producing the smooth surface we desire. Experimentation is continuing with good assurance of success.

We feel this is the first step toward the removal of the hand grinding room and its ultimate success is well worth striving for.

HOT PLANETARY STRIP MILL

Because we could not justify the extremely high capital expenditure necessary for conventional hot mill procedures in the rolling of strip, we decided to pioneer again in a revolutionary type of hot mill and installed the Sendzimir hot planetary mill followed by a 2-high planishing stand.

Steel is heated in a hi-head furnace 74 ft 6 in. long. Slabs enter cold and progress through the furnace at speeds of 6 to 10 fpm, emerging to enter the mill at the desired temperature of 1700 to 2200 F. Slabs vary from 7 ft 10 in. long to 34 ft long and from 10 to 19½ in. wide. Thicknesses vary a little but generally we maintain 2¼ to 2½ in. maximum.

In operating a planetary mill the work is forced into the planetary work rolls by two sets of feed rolls which are mounted in the same housing. In addition to pushing the steel, the feed rolls reduce the slabs about ¼ in. each. The slabs are butted end to end so that one slab pushes the back end of its predecessor through the mill. In order to maintain alignment the slabs are centered by hydraulic centering devices through the furnace, and by a set of roller guides located ahead of the feed rolls. Provision is made to speed up the feed rolls in order to close any gap that may occur between the slabs.

The feed rolls are 17¾ in. diameter, have a 28-in. face and are driven by 35-hp motors. They are smooth finished and straight faced.

Figure 3 shows the basic principle of the planetary mill in which you see the work rolls—3⅝ in. diameter x 24⅛ in. long—surrounding a backup roll of 27 in. diameter with a 24-in. face.

There are 48 small diameter rolls, equally spaced about the two backup rolls, enclosed in cages which are mounted on the backup roll necks. The backup rolls are driven in the direction of the strip travel by a 1250-hp synchronous motor through a gear reducer at the rate of 297½ rpm. The work roll cages are driven in the same direction as the backup rolls through an air clutch from the mill drive at a speed of 146 rpm. The difference in speed between the backup rolls and the cage assembly causes the work rolls to revolve at a speed of 1130 rpm in the opposite direction to the strip travel. The cage speed is very critical since an increase or decrease changes the relative speed of the work rolls compared to that of the backup rolls.

The distance between successive work roll bites on a slab causes each work roll to drive and elongate a small portion of the material along the roll bite. The 2½ in. slab which has been reduced to 2 in. through the two

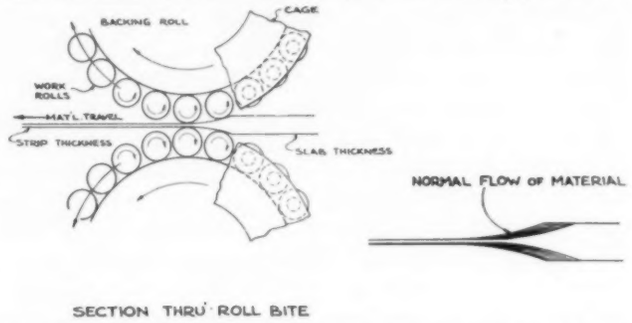


Figure 3 — Very heavy reductions can be taken with the planetary mill.

sets of feed rolls is pushed against the planetary set and reduced to 0.1 in. or whatever presetting is made. Because of the extreme reduction taken, the edges of the slab are rounded so it will not "V" inward as occurs with a straight-edge slab. Also, the first slab rolled during the day is chamfered to allow easy entrance into the work rolls.

Experimentation has been necessary on different types of steel to produce a proper edge. The "V" edge cools rapidly which promotes edge cracking and tearing.

Once the mill is set up for rolling with the proper allowance for spring, there is not too much actual operating that the mill operator can do other than to be alert for emergencies that may occur due to cobbles, etc. His most positive control is to see that the slabs are butted well in order to have the rolling operate continuously. When the last slab is through the feed roll, there is no more positive pressure on the slab and the amount of metal between the roll bite and exit side of the feed roll is scrapped. At this juncture the operator opens the planetary rolls wide and allows this section to be pulled through the mill to the coiler where it is cut off.

The operation of the planetary mill is, of course, a new departure in rolling. The main weakness to be overcome was the bearings on the work rolls. These are needle bearings of necessarily small size. We found in our early rolling program that water was getting into these bearings from the cooling water on the mill. This water corroded the bearings causing them to seize during operations. This has been overcome by forcing oil through the bearings after shutdown and increasing the amount of lubrication to the bearings during operations.

We still expect bearing design to improve and change. We have a set of bronze sleeve bearings in operation now which have run 600 tons with no apparent damage.

We also found that the feed rolls should be hot to make quality steel and control tracking. Heating of the solid feed rolls promoted checking and breakage. We have put in redesigned feed rolls of sleeve design with water cooling for the bearings on the shafts. This has enabled us to control tracking of slabs through the mill and prevents chilling of the surface. It also solved the problems of tracking and surface.

During the early stages of rolling on the planetary mill it was proven that if tension was not kept on the strip after leaving the mill, buckling developed and prevented the strip from being coiled. For this reason a set of pinch rolls would be required after the mill, or the coiler would have to be placed close enough to the mill, to maintain this tension. However, with the coiler too close, trouble would result in unloading. It was decided that, if a set of pinch rolls were needed, we would do better to place in the location of the pinch rolls a 2-high stand capable of taking some reduction on the strip. This would enable us to produce a 20 per cent thinner hot rolled band.

Two tanks are employed and both are filled with a salt—substantially sodium hydroxide with certain additions. The strip passes between negative grids in the first tank and positive grids in the second. Since the tanks are insulated from each other, the current follows the strip and maintains the efficiency of the operation. The salt is heated to 900 F. Current is supplied at 18 volts, 5000 amp, from two motor-generators only when descaling hot rolled strip. The salt alone is able to descale the cold rolled strip. On cold rolled strip, therefore, the generators are used on the nitric acid tank or sulphuric acid tank which is set up for electrolytic pickling.

GENERAL COMMENTS

The economic advantage of continuous casting can only be realized if each heat is completely tapped and cast into the desired billet. The usual measurement of this advantage is in metal yield. Metal yield can become a very confusing yardstick unless one defines clearly what the term really means. For instance, in normal practice when talking yield one usually refers to the metal recovered on the hot bed from ingots. When attempting to evaluate the results of continuous casting one becomes aware of yield variations which caused little concern normally. Melting yield becomes a daily factor because we no longer have a short ingot or butt. Also, variation in ingot body weight due to mold wear is greatly noticed.

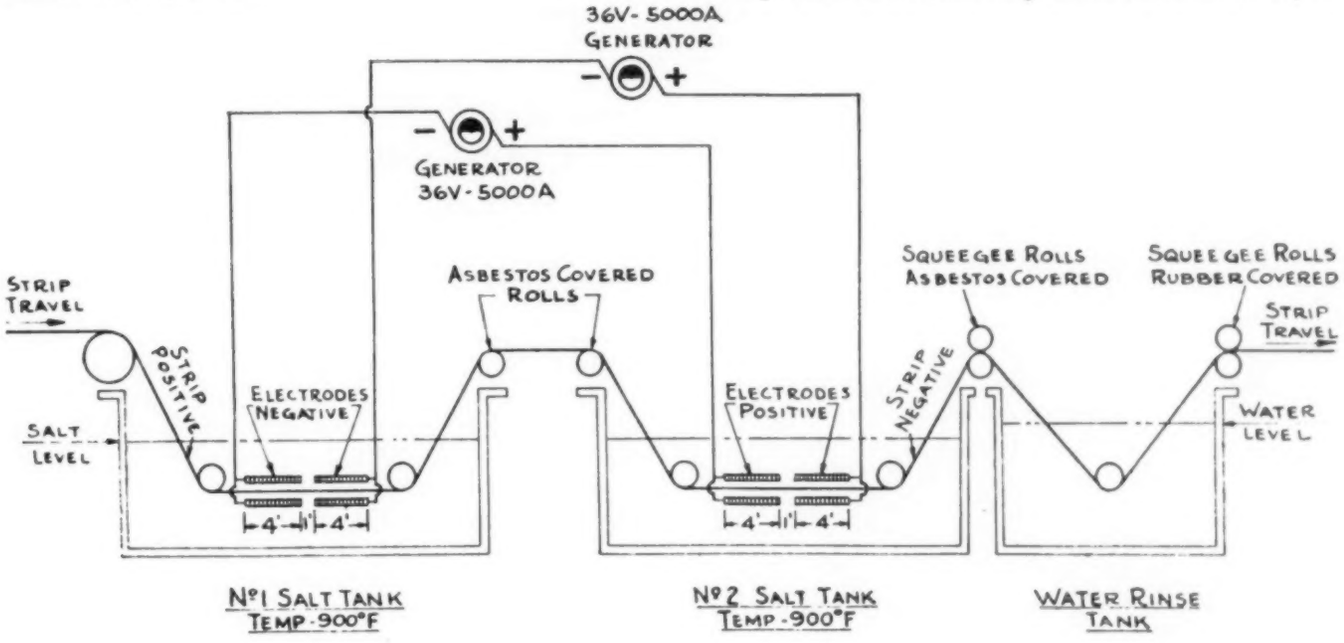


Figure 4 — Schematic diagram illustrates layout for continuous descaling of steel with a hot salt electrolytic bath.

We have therefore placed a finishing mill 9 ft center-to-center after the planetary mill. The rolls in this mill are 22½ in. diameter x 30 in. long, with composition bearings lubricated with both grease and water and driven by a 250-hp motor. A looping roll is mounted on the entry side of this mill to control the strip tension between the planetary and finishing mill. It is operated by a separate operator who actually has more control over the rolling than the planetary mill operator, since he can increase or decrease the speed, put tension between the mills and adjust the screws during operation.

ANNEAL AND PICKLE LINE

Having decided against a mechanical scale breaker, experimental work was undertaken which resulted in the continuous electrolytic salt descaling process. Figure 4 shows the features of this installation.

In continuous casting, therefore, we report various yields as illustrated by the following tabulation of run No. 118, heat No. 1840C, Stainless 302. Cold weight charged in furnace was 53,377 lb. Tapped weight sent to continuous casting machine was 51,165 lb. Melting yield was 96.0 per cent. Losses at continuous casting machine were: 300 lb left in tundish, 200 lb bottom discard, 150 lb test, and 400 lb skull in ladle. Billets forward to the mill 50,115 lb. Casting yield 98.0 per cent.

Material rolled at mill to strip and sheet slabs produced 47,450 lb. Clogging yield 94.5 per cent. This, then, gives a yield from cold metal charged in the melt shop to billets on the hot bed of 88.9 per cent.

Many times yield from ingot figures have been confused by using an estimated ingot weight from which to calculate billet yields to two decimals. For several months, in order to get comparisons, we weighed every ingot cast and determined a normal melting yield of 92 per cent with from 1½ to 2 per cent of the metal in the short ingot or butt.

During this period our average weighed billet yield was 78.6 per cent. This gives an overall yield of 72.5 per cent.

Increased yields are obtained by using the continuous casting process because no top and bottom discards from individual ingots are required. However, a further increase in yields is obtainable over and above that by being able to cut billets on the continuous casting machine which will roll to exact lengths. This is not possible from ingots as often as it is desired. However, this yield increase is obtainable only if the cross section of the billet produced is kept constant. Also, as far as the melt shop is concerned, the yield loss from the last ingot cast or the butt or short is eliminated and this metal is saved as well. The melt shop economy can only be realized through this increase in production.

There will be little manpower saving in the melt shop, because the men must be used on the continuous casting machine. If part of the heats are to be ingot cast, the manpower requirements may even increase.

The continuous casting machine will eliminate the use of the ingot mold, thus lowering capital investment, and solves the difficulty of the deteriorating surface of ingots as mold life increases.

In the operations at Atlas we have in our repertoire some 250 compositions of which as many as 150 are melted in any one month. For the first five months of 1954—using an average of all the metal cast—our pit and hot top cost was about $8 per ton. From preliminary operations on our continuous casting machine it is estimated that if we can put through about 2500 tons of metal per month the $8 per ton pit and hot top cost will be equalled.

During all the experimental work on the machine in learning to operate it we were only able to use one shift a day casting on heat. In order to increase to the desired tonnage, it will be necessary to do about 24 heats per week. We are now training the second operating crew in order to approach the time when the casting and pit costs will equalize. At this tonnage we will realize for the melt shop the saving of the increase in yields.

Some changes were required in our blooming mill roll designs in order to produce the 19½ in. wide slab which we wished to put on the Sendzimir planetary hot mill. Our normal procedure in producing the 19½ x 2¼ in. thick slab is to start out with a 22 in. ingot and take 32 passes. With continuous cast slabs we went to a 13-pass setup starting with the continuous cast slab at 21½ x 5½ in. This is a reduction of over 50 per cent of the actual time between the rolls and a corresponding reduction in handling, since the slabs handle more easily than the ingots.

We also have in our continuous casting setup a 5½ x 7½ in. mold which is equivalent to a section of heat-resisting alloys rolled on our blooming mill. This section is further rolled to produce a 3-in. square. With conventional rolling, we used a 14-in. ingot. Now we not only show a saving of 18 passes or 56 per cent, but also save a reheat after the 14th pass. At other times it is our practice to condition a bloom at 5½ x 7½ in. from the ingot so that a second heating in that case is from cold.

Some of our higher alloy steels are cast in 6¾ in. ingots and are cogged to 4¼ in. square before going to the finishing mill.

The use of the continuous casting machine is especially bright in the production of flat-rolled products. The casting of wider and wider slabs is most definitely to be achieved. Even now there is under consideration a hot planetary mill 42 in. wide. The coupling of these developments will make a decided change in the capital investment required for the future.

"THE CLEANING OF OPEN HEARTH STACK GASES"

by LESLIE SILVERMAN, Associate Professor of Industrial Hygiene Engineering, Harvard University School of Public Health, Cambridge, Mass.

▲ BASICALLY, the problem of open hearth stack gas cleaning must be considered on the premise that the economics of cleaning is paramount. The economic factor which confronts the operator is that the cleaning of the open hearth stack gas does not result in any obvious material advantage. Rather, he is preventing possible litigation and complaints and is desirous of living in harmony with the resident community. The situation in this regard can be pointed up by noting that the amount of fume discharged by a typical open hearth furnace, for example a 250-ton per 8-hour heat furnace, an average size, is on the order of 1 to 3 tons of fume per day, assuming average operating conditions. The material value of the recovery of this fume, even at an efficiency of 100 per cent, would hardly offset the cost of the cleaning installation. When one realizes the market value of this fume, which may contain a maximum of 50 per cent iron oxide, as being less than that of a ton of ore the low return is apparent. The tangible recovery of the effluent from the open hearth furnace can only result in an added cost of handling and possible difficulties in metallurgy within the installation. This situation, of course, is contrasted with blast furnace operation where the material recovered and the cleaned gas can be used for economic purposes. These, over long period amortization, do offset some of the capital cost of the cleaning equipment.

In discussing the problem of the cleaning of open hearth stack gases one must consider the gas volumes involved, their composition, particulate materials pres-

ent in the gas, their particle sizes, and temperatures and conditions of the discharged gases. The quantity of fume evolved from open hearth furnaces depends somewhat on the nature of the furnace and its operation and the alloy produced but for practical purposes the gas volumes and particulate loadings can be stated to lie within a certain range. For this consideration a typical 250-ton furnace will involve the discharge of about 25,000 standard cu ft of air per minute with an average loading in the effluent of approximately 0.4 grain per cu ft of extremely fine fume. In addition to this fume, the result of vaporization of iron and other materials in the furnace, there are sulphur gases from the fuel. Sulphur gas concentrations vary widely depending upon the type of fuel used.

The chief difficulty attached to the problem of open hearth gas cleaning is the fact that the mean size of the fume by weight is composed primarily of particles below 5 microns. Our tests indicate a mean size in many instances of less than 0.1 micron by count. This means that a tremendous number of extremely fine particles, much finer than tobacco smoke, are discharged into the atmosphere. These, unfortunately, are of a high light obscuring nature, and will produce a plume which is visible for many miles. The problem is difficult because of the fineness of the fume which attracts public attention because of the strong reddish color of the light obscuring particles. This color is very persistent under normal daylight conditions.

Another major cleaning difficulty influencing simple solution of the problem is the fact that the fume is discharged from the furnace at temperatures ranging from 1100 to 1500 F. Although many operators incorporate a waste heat boiler to recover the heat and thus reduce the volume of gases (by reducing the discharge temperature to 500 to 600 F), it still remains a fact that the cost of cleaning in many instances must also include the cost of the waste heat boilers used to reduce temperature since the steam produced is not always necessary.

REQUIREMENTS FOR CLEANING

It might be stated at this point that the industry has been reluctant to install cleaning equipment on open hearth stacks because of the high cost of equipment necessary to provide a satisfactory effluent to eliminate the nuisance or objectionable loss of visibility. It has been the experience of those operators who have made such installations that very expensive equipment such as electrostatic precipitators has been necessary. To date, there are few ordinances which have been applied specifically to open hearth furnaces except in areas such as Los Angeles and Allegheny County. In Los Angeles, an emission limit is specified; that is, limiting discharge to a given amount per hour per stack on a basis of the total amount of material charged to the operation (furnace in this case) but not permitting any more than 40 lb per hour for any given stack. Because average size open hearth furnaces exceed 30 tons of raw materials charged per hour, the 40 lb per hour limit applies. In essence the efficiency to meet this is dependent upon stack loading and gas volume. Thirty tons of steel production per hour can produce 300 lb of fume, hence an efficiency of $\frac{300 - 40}{300}$ 100 or 87 per cent is indicated. The rule as used in Los Angeles is being considered for adoption in other cases. In Allegheny County, open hearth furnace operators have been instructed to incorporate those means of controlling emissions to the atmosphere which have proved economically sound. Furthermore every operator was requested to undertake a research program to determine practical methods for controlling furnace emission. Permission was given to extend the research program up to five years and longer if necessary.

Other limitations which have been placed on open hearth furnaces have been largely on a basis of the industry's desire to avoid community problems. For example, the new Fairless Works, in programming, incorporated open hearth control by means of electrostatic precipitators before completion of the facilities. We must contrast, however, the cost of rapid amortization of such equipment which was possible in the latter case and also the lowered cost when assessed against a new facility as against the problem which faces operators required to install fume control on existing furnaces. Because of these problems and since the methods for cleaning which have been applied to date have been expensive and not absolutely satisfactory in some instances it became apparent that further research was necessary.

We therefore reviewed the needs of many major producers and considered the mechanical factors involved. It was ascertained that a 95 per cent or greater weight removal of fume particles below 5 microns would, in most instances, be necessary to eliminate the visible plume. In addition to this, another important requirement influencing the type of cleaning device to be developed is the resistance to gas flow introduced by the unit. Most of the operators agreed that an additional resistance of 4 in. of water could be tolerated since existing waste heat boilers have already imposed resistances of this magnitude. Power costs would not be abnormal under these conditions. The answer to the question of "where should the cleaner be located?" varied widely in many discussions. Some felt that if a cleaner could be developed which would operate without a waste heat boiler or before an existing waste heat boiler it would have numerous advantages. However, it is obvious that cleaning before a waste heat boiler eliminates the problem of blowing boiler tubes, improves heat recovery, and reduces maintenance problems. Also if a waste heat boiler is not employed a sizable fraction of the installation cost is eliminated. From a pure economic standpoint it seems unnecessary to permit the energy available between 500 and 1200 F to be dissipated without recovery. Another feature also which makes the waste heat boiler or heat exchanger attractive is the fact that the discharged volume of gases is reduced.

BASIC RESEARCH PROGRAM AT HARVARD

In view of the present situation and the fact that open hearth cleaning may be necessary, the Subcom-

mitee on Air Pollution Abatement of American Iron and Steel Institute recognized that some fundamental research into the whole problem of open hearth stack gas cleaning was essential. In November 1953 a research program was initiated at Harvard on methods of controlling and removing effluent fumes resulting from open hearth furnaces.

Our attack on the problem has been in two basic areas. One phase which we have called agglomeration studies involves an investigation to ascertain how particle size of the fume may be increased to make applications of simpler collection techniques practical such as equipment which can function easily at high temperatures and with coarse particles ($> 5 \mu$). For example, mechanical collectors on flyash from power plants yield much higher results (85-90 per cent) than the same equipment applied to open hearth collection.

This phase of the project has not proceeded as rapidly as the second phase in which studies have been made on the development of an inexpensive filtration method. In attacking the problem from the standpoint of agglomeration we also recognized the fact that any improvement in particle size could enhance performance for other collection methods even though we were not completely successful in increasing the size to the point where a mechanical collector would collect appreciable amounts of fume. Increase in particle size would be of assistance in filtration devices, in simpler scrubbing devices and would simplify the problem of fume handling after collection. Such treatment would not interfere with or alter the characteristics of electrostatic collection.

The major reason we undertook to attack the problem from a filtration standpoint was our experience in cleaning sub-micron size radioactive aerosols by means of filtration techniques. Requirements for cleaning for radioactive aerosols are usually more exacting than the air pollution control problem for nuisance materials such as iron fume. One of the attractive methods for filtration is the use of layers of extremely fine fibers. In appraising the problem from a fundamental standpoint we felt that some of the work we had done during the war on the development of gas mask filters might be applicable. One of the materials which had proved attractive in this study was fine fiber slag wool (average size 4 μ) which had been utilized in preliminary filtration studies as a possibility for a cheap source of material for civilian gas mask filters. Another feature of slag wool which appealed to us was the fact that it is a refractory or temperature resistant material of low cost.

On a basis of the laboratory studies it was found that successful filtration could be obtained at resistances in the range of 4 to 6 in. of water at velocities as high as 200 fpm and efficiencies ranging from 85 to 95 per cent. It is important to emphasize velocity here because as contrasted to bag filtration equipment already mentioned where 2 to 3 fpm are necessary we believe that for practical applications it is necessary to reduce the cross-section of the filter to a reasonable value and thus favor velocities greater than 50 fpm. For example, if one were required to filter 25,000 standard cu ft per min at a temperature of 500 F it would represent approximately 50,000 cu ft per min. It would be necessary to permit only a reasonable cross-sectional area to the collector and hence assuming a velocity of 200 fpm the area would be 250 sq ft or a filter 25 ft wide and 10 ft long or roughly 16 ft square.

The problem of economics and its relation to useable life of the slag wool fiber was apparent to us early in the investigation. The early laboratory studies demonstrated the feasibility of the material and the method and it was necessary to determine whether the economics were within reason. Calculations showed that the economics would not be desirable on single pass use even though slag wool costs approximately 1¢ per lb at the plant.

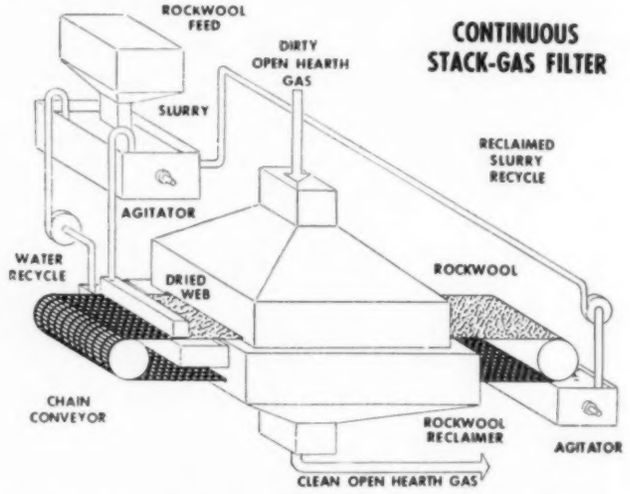


Figure 1 — Schematic drawing shows principle of operation of continuous slag wool stack gas filter unit.

After sufficient information was obtained in the laboratory and on small scale field studies, a pilot unit was constructed which could handle 500 to 1000 cu ft of gas. The principle of this unit is shown in Figure 1 of the actual pilot unit as installed at the Saucon Works of the Bethlehem Steel Co. We have evaluated this unit over a three month period and in general, performance on the pilot scale compares very favorably with laboratory studies although there has been some mechanical difficulty with the formation of continuous beds. These pilot studies, to date, showed that difficulties with the method result because the apparatus has not been completely mechanized for filter layer formation. With a continuous operating filter uniform beds would be produced since some of the spotty results we obtained were because of non-uniform density filter layers. Another mechanical difficulty which developed in the field tests was leakage through the equipment because of the thick conveyor chain. We have obtained enough field information to indicate the mechanical improvements necessary to make the method feasible on a large scale.

On a basis of this study we have demonstrated to our satisfaction that the mechanical continuously formed recycled filter method can yield the desired results and on an economic basis it is apparent that capital cost of this equipment will be substantially less than that of present precipitator installations. It is now apparent to us however that the problem of installation when

the cost of the collection equipment is only 20 to 30 per cent of the total should also be evaluated. We found that one of the major problems in installation is the high cost of piping and mounting of equipment. The ideal approach would appear to be a collection device which surrounds the open hearth stack or can actually enter the stack with minimal support. This all points towards reducing the size and physical dimensions of the cleaning equipment and to proceed on a basis which would provide adequate performance with a little interference with operations. Another procedure which we propose to evaluate in this regard is a continuous moving filter bed with wool production, *in situ*. This would not require separate slag wool facilities and material could be recycled dry. Heat balance studies indicate that the fuel costs are not unreasonable for this approach. A device of this type is shown in Figure 2.

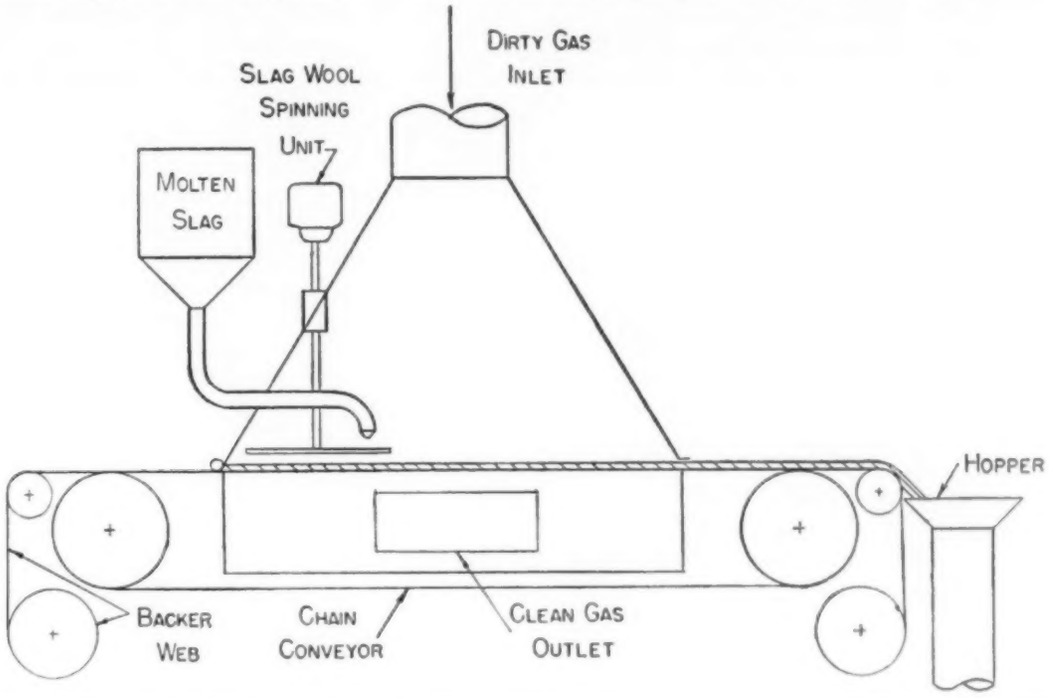


Figure 2 — A continuous filter is formed by continuous generation of the slag wool.

AGGLOMERATION STUDIES AND THEIR RELATION TO FILTRATION STUDIES

In view of the possible need for combined agglomeration and a compact filtration approach we believed it possible to develop a device which might include agglomeration principles and at the same time comprise a collector which could be adapted to fine metallurgical fume.

We thought that by producing mechanical agitation of the gas it might induce agglomeration and also provide additional surfaces for contact and cooling. The simplest concept of this device consists of a rotating

TABLE I

Preliminary Collection Data on Performance of Rotating Screw Device
Laboratory open hearth simulant iron carbonyl combustion fume
Mean inlet temperature 494 F
Iron oxide loading 0.045 grains per standard cubic foot
Temperature drop through unit 320 F
Screw agglomerator 2 in. pitch, 3 in. diameter, 26 in. long

Speed of rotation	Direction	Resistance* In. of water		Efficiency by weight, per cent	Remarks
		70 F	500 F		
Screw removed	None	0.07	0.09	48.0	Varies with tangential velocity from 40 per cent at 21.5 cfm 50 per cent at 26 cfm 58 per cent at 30 cfm 1.5 in. entry 4000 fpm at 25 cfm and 500 F
Screw stationary	None	1.0	1.4	53.0	
1000	Forward	0.67	0.9	57.5	
1750	Forward	0.60	0.8	56.0	
2550	Forward	0.73	1.0	51.0	
1000	Reverse	0.82	1.1	55.5	
1750	Reverse	0.97	1.3	57.5	
2550	Reverse	0.97	1.3	55.5	

*Does not include resistance of tangential entry or exit, approximately 0.4 in. of water at stated velocity.

screw of the screw conveyor type with a slot discharge arrangement for collected material and a tangential inlet. We were obviously interested in developing a device which had minimal resistance to flow. Consequently the screw was motor driven. Preliminary studies indicated that we could operate the screw so it acted as an air mover and its air flow resistance was negligible.

Studies of this unit as a dynamic device for collection to date have only been made with laboratory fume at elevated temperatures. The results so far have been encouraging in that the unit removes 40 to 50 per cent of the fume generated by the techniques used for the filtration study. These results have been so surprising that we are reluctant to comment further without more investigation. The development of the screw concept, of course, involves small radius centrifugal separation but adds a new feature to mechanical collectors; that is, while rotational separation is taking place a continuous method of removing collected material from the air stream is employed and thus is prevented from re-entrainment. This device can become an inexpensive mechanical collector of reasonably high efficiency for the size of fume involved. The effect of forward or backward rotation can be seen from the data presented in Table I. The screw improvement over the unit without the screw present is 20 per cent indicating that most of the effect of tangential separation is due to cyclonic action. The screw proves desirable from several considerations, namely providing a means of continuously entraining fume for agglomeration in the unit, positive separation to prevent re-entrainment, and also a means of externally reducing resistance.

The other part of our research program which combines the filter and agglomerator study and also our desire to reduce the overall size of equipment is shown in principle in Figure 3. The agglomeration techniques described above can thus be incorporated with continuous slag wool addition in the latter phases as a continuously moving rotating filter bed. Mechanical details of this device are only in pilot laboratory experimental scale development and it is too early to make comments on performance. Since we have demonstrated the feasibility of the fibrous material and have also demonstrated the possible effectiveness of the agglomeration techniques this solution appears to offer promise for combining agglomeration and filtration techniques. The separation of the wool from the air stream leaving the screw unit will be done by a rotating screen. The wool can then be returned to solution and cleaned for reuse.

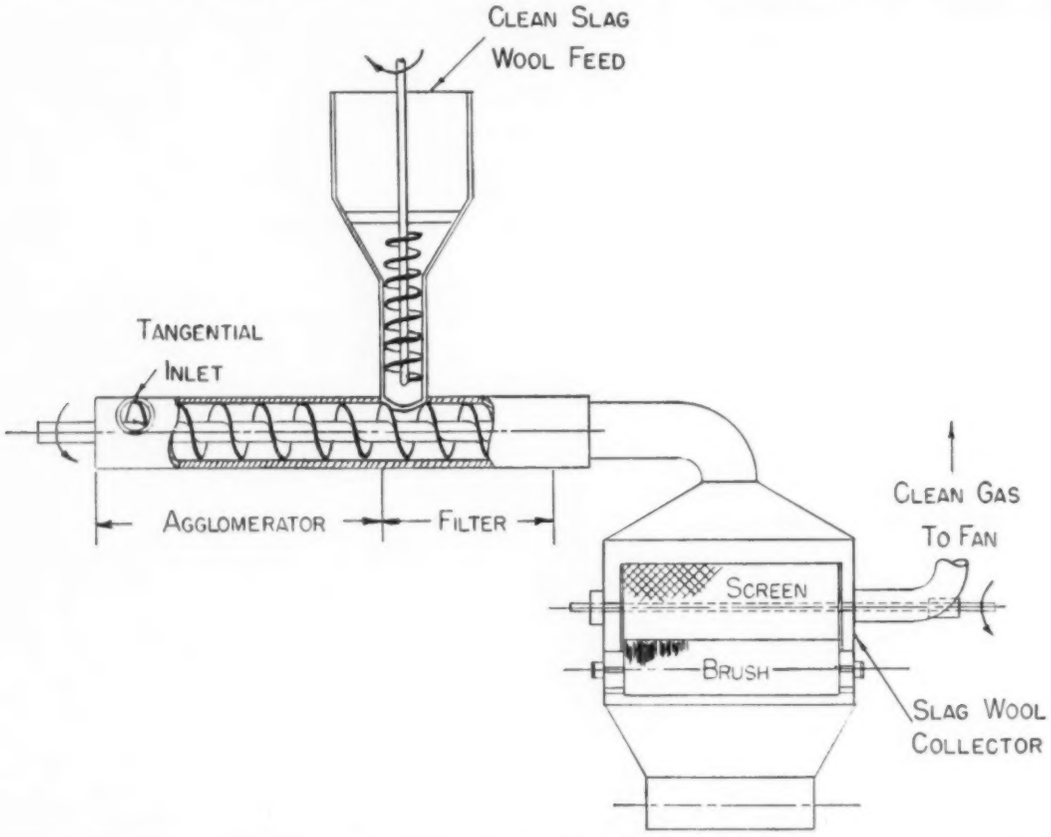


Figure 3—Advantages are indicated for combining the screw agglomerator, inertial collector and continuous filter.

"COKE QUALITY AND BLAST FURNACE OPERATING PRACTICE"

by W. T. ROGERS, Product Engineer, Lorain Works, National Tube Div., United States Steel Corp., Lorain, Ohio

▲ ONE of the important problems in the iron and steel industry is the evaluation of coke with respect to its efficiency as a metallurgical fuel in the blast furnace.

This multiple variability of coke characteristics and blast furnace operating practice presents a somewhat complicated problem from the standpoint of evaluating the separate effect of coke quality. However, with the use of multiple correlation the two effects can be cal-

culated individually and thus, by determining the effect of various blast furnace operating variables and correcting for their influence on iron production, coke rate and dust production, the remaining independent relations with coke characteristics can be evaluated. The problems in handling data for multiple correlation analysis also have been greatly reduced by the use of punch cards and tabulating equipment.

PROCEDURE

The procedure for making this study consists in assembling the data from blast furnace operating and coke plant laboratory reports by months for the 4-year interval of 1950-1953 inclusive. The five furnaces in operation at the plant in which the study was made were included as a unit and all blast furnace data used are on a monthly average basis. The data on coke consist of monthly averages of daily chemical and physical property test reports.

The data were tabulated in code and punched on tabulating cards from which the necessary computations for the construction of a correlation matrix were developed. From this matrix the multiple regression constants, the correlation coefficients and the standard errors were calculated. Multiple regression estimating equations were then developed for each dependent variable from which the straight line relationships with each independent variable were then calculated and plotted. The regression equations were then applied to each monthly set of data and an estimate of the dependent variable made. Differences between actual and estimated values were averaged for various increments of the independent variables and plotted as deviations from the straight line relationships with the result being shown as a series of graphs. The mechanics of this method of handling data are now rather common and more detailed explanation is not believed necessary in this paper.

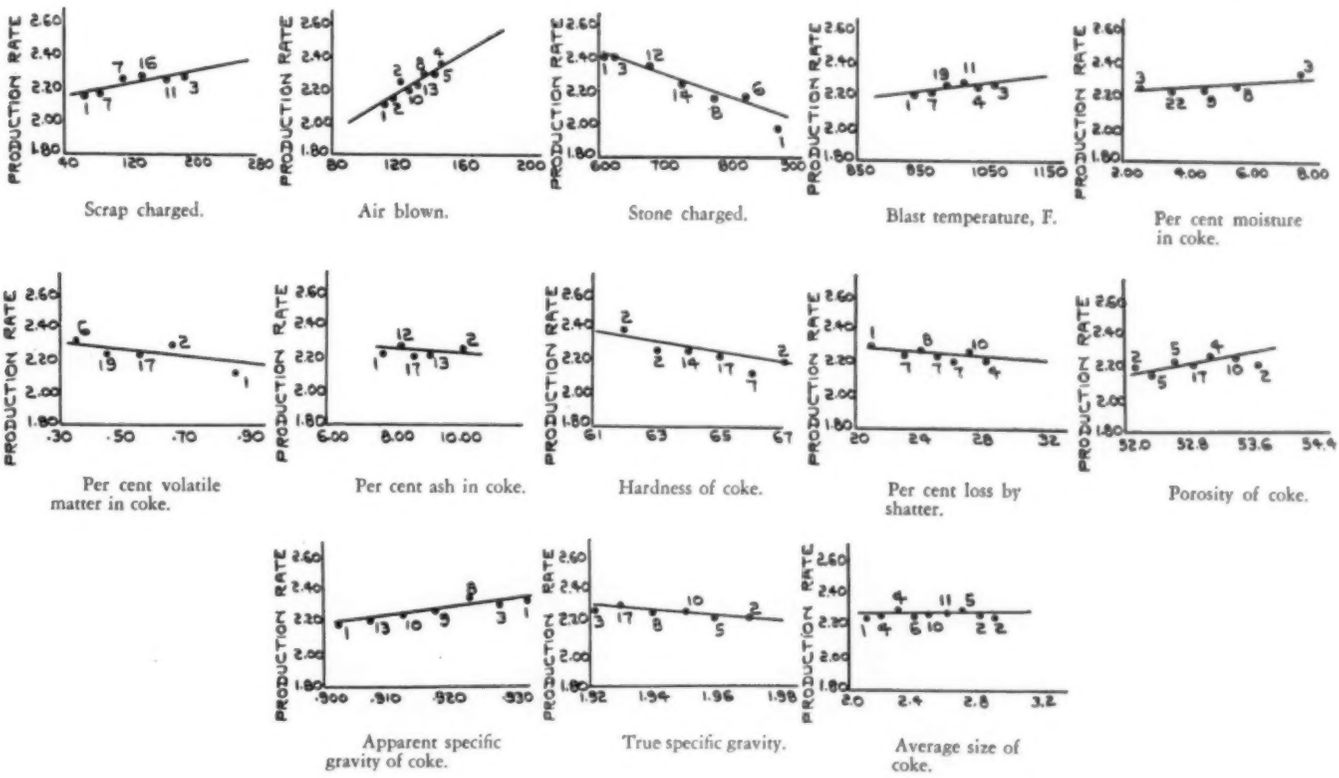
THE REGRESSION COEFFICIENTS

Production rate—In discussing multiple regression equations in industrial applications, it is well to bear in mind their limitations. It is true that from a given set of statistically termed "independent variables" under certain conditions of high correlation and low standard error of estimate an estimating equation can be derived which will in total give a calculated result of a "dependent variable" which agrees closely to an individual actual observation. It is not implied, however, that each "independent" regression coefficient represents the actual separate effect of the particular factor under consideration. This would only be true if no strong intercorrelation among the independent variables were present.

One of the most important characteristics of a blast furnace is its productive capacity. This is generally measured in tons per square foot of hearth area per day which is the unit of measurement employed in this analysis. The multiple regression equation developed with the independent variables and production rate is as follows:

Production Rate $= -2.3262 + 0.00092 \times$ scrap charged $+ 0.00612 \times$ air blown $- 0.00139 \times$ stone charged $+ 0.00047 \times$ blast temperature $+ 0.01540 \times$ per cent moisture in coke $- 0.21020 \times$ per cent volatile matter in coke $- 0.00710 \times$ per cent ash in coke $- 0.02490 \times$ hardness of coke $- 0.00640 \times$ per cent loss by shatter $+ 0.08748 \times$ porosity of coke $+ 4.9560 \times$

Figure 1 — Curves show variation in production rate for various factors which affect blast furnace operation.



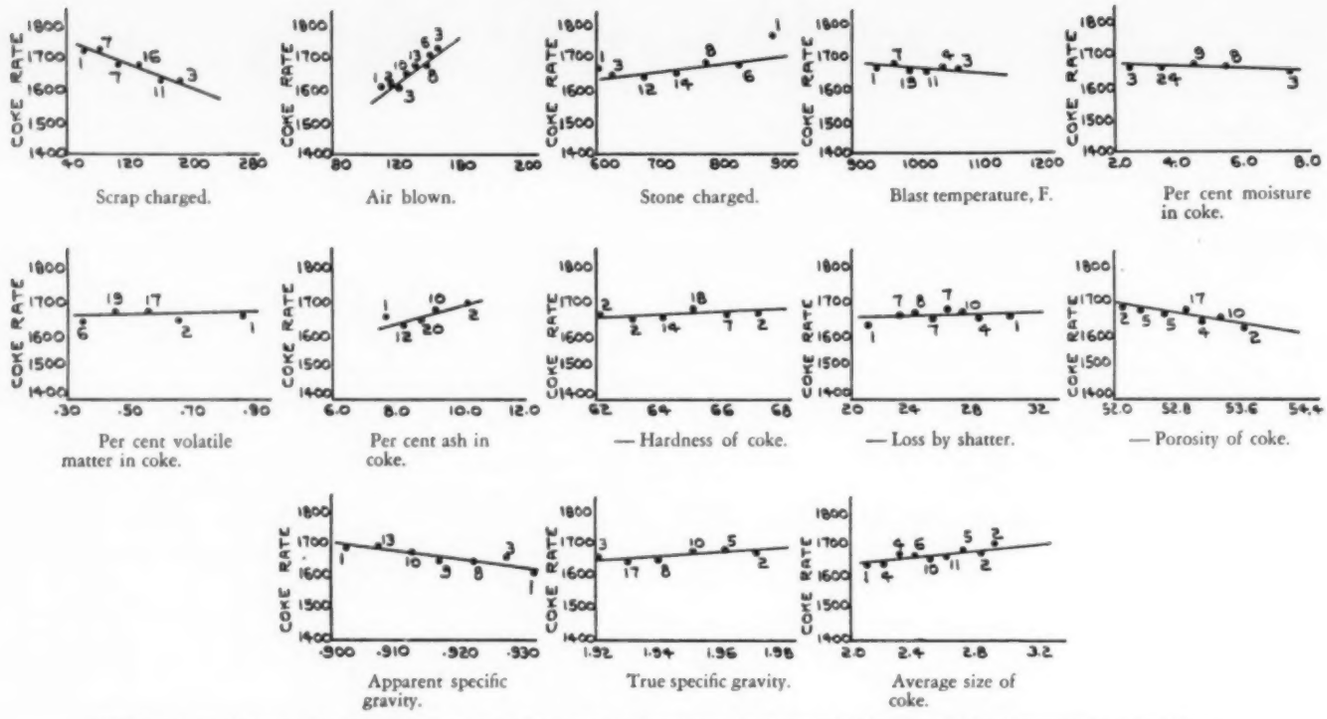


Figure 2 — Curves show variation in coke rate for various factors which affect blast furnace operation.

apparent specific gravity of coke — 1.5860 × true gravity of coke + 0.00170 × average size of coke.

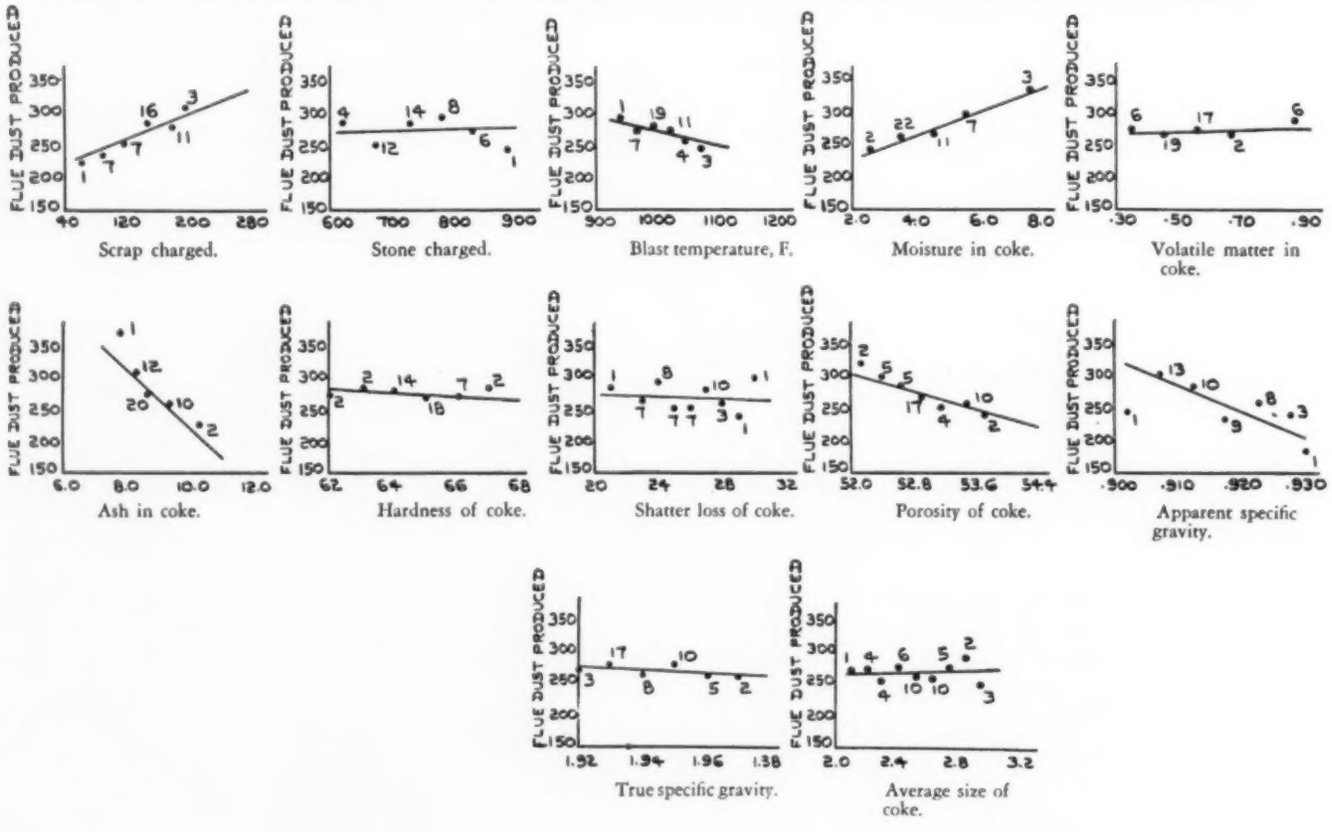
The independent relations represented in this equation are shown graphically in Figure 1.

Coke rate—The next most important variable with respect to blast furnace performance is the coke rate or the pounds of coke necessary to produce a ton of iron. The net regression equation for estimating this characteristic is as follows:

Coke Rate = + 3405 — 0.9353 × scrap charged + 3.4920 × air blown + 0.2486 × stone charged — 0.1432 × blast temperature — 5.1800 × moisture in coke + 21.9900 × volatile matter in coke + 26.8700 × ash in coke + 65.1204 × hardness of coke + 25.9089 × per cent loss by shatter — 40.2430 × porosity of coke — 2386.4000 × apparent specific gravity + 757.8000 × true specific gravity + 53.7400 × average size of coke.

Figure 2 presents graphically the relations developed

Figure 3 — Curves show variation in flue dust produced for various factors which affect blast furnace operation.



with blast furnace operating practice, which show that coke consumption is reduced with increased scrap charged and higher blast temperatures. The other operating factors, air blown and stone charged, indicate positive relations with coke rate increasing in direct proportion to each unit increase in the respective variable.

Dust production—The relations with dust production result in the following equation: Dust Production $= +6929 + 0.5235 \times$ scrap charged $+ 0.0177 \times$ stone charged $- 0.2118 \times$ blast temperature $+ 18.2800 \times$ moisture in coke $+ 1.3800 \times$ volatile matter in coke $- 46.5900 \times$ ash in coke $- 2.2900 \times$ hardness of coke $- 0.4540 \times$ loss by shatter $- 34.9230 \times$ porosity of coke $- 4078.7000 \times$ apparent specific gravity $- 248.3000 \times$ true specific gravity $+ 8.8500 \times$ average size of coke.

These independent relations are presented in Figure 3.

MEASURES OF CORRELATION

The regression coefficients show the average change in the dependent variables, production rate, coke rate and dust production which is associated with each unit change in the various independent variables. This permits the estimating of expected average values for a specific dependent variable for various combinations of the independent variables within the range of data used in the analysis. This does not, however, evaluate the accuracy or reliability of individual estimates. This evaluation can be made by the use of three other statistics, the correlation coefficient, the coefficient of multiple determination and the standard error or estimate.

PRACTICAL APPLICATION

The practical application of the results of this type of analysis is in its ability to explain the various individual high and low values encountered in the production process and also to determine the causes of various trends which occur from time to time.

Another practical application is found in answer to the question, "What proportion of the variation in blast furnace performance is associated with operating practice and what proportion with variations in coke quality?" This separation cannot be made positively because some of the variability attributed to coke quality is included in variability associated with operating factors. However, by determining the coefficient of multiple determination between the independent blast furnace operating variables and the dependent performance variables and subtracting this from the total coefficient of multiple determination including coke quality factors a figure is derived which represents the maximum amount that can be assigned to coke quality variables only.

It was apparent that in this particular study variations in blast furnace practice have more influence on performance than variations in coke quality. It should not, however, be inferred from this interpretation of the data that coke quality is of minor importance but rather that during the period covered in this analysis the various coke characteristics were held at such a constant level that the effect of their variability was not sufficiently pronounced to be reflected as the major factor in blast furnace performance variations.

At the plant where this study was made, the practical applications presented in this paper are in constant use. The coke plant and blast furnace operating supervision together with the metallurgical department have formed a coke quality and blast furnace committee. This group meets regularly to discuss current problems of individual or collective interest. The results of this type of analysis are used in these meetings as a basis for evaluating variability of coke and blast furnace performance, and have been of valuable assistance in helping to improve coke quality and analyze blast furnace production problems.

"PRODUCTION CONTROL OF QUALITY STEELS"

by R. W. GRAHAM, General Superintendent, Duquesne Works, United States Steel Corp., Duquesne, Pa.

▲ THIS paper proposes to consider the present day steelmaking problem from the viewpoint of an operator who is responsible not only for quality, but who is also responsible for plant economics. It does not propose to argue the need for or the validity of existing specifications, but rather constitutes a progress report on the various steps being taken to meet present day quality requirements. The term "quality steels" is used to describe a broad range of products that might possibly be classified as special purpose steels. These steels include carbon alloy, and stainless grades and for the most part represent the materials used in the manufacture of working parts which are subject to extreme stresses in service or to exceptionally difficult usage in fabrication.

The Duquesne Works of the United States Steel Corp. produces an extremely wide range of open hearth and electric furnace products. Since this operation furnishes valuable background for a discussion of the steels in question, frequent reference will be made to Duquesne, and much of the experience depicted will be taken from its operating and metallurgical records.

Basically, quality control consists of establishing proper and adequate practices and then following those practices to the most minute detail. This strict adherence must apply not only in melt shops but throughout all operations—from the procurement of raw material to the shipment of finished product. It even applies beyond final shipment since it is necessary to correlate performance of the end product with the practice established in the shop.

Quality control includes detailed observation and recording of actual practices. It involves voluminous statistical studies which can now be made more readily and completely by modern tabulating methods. It requires extensive machine shop and laboratory facilities for routine testing as well as for development work. It includes inspection with the best facilities available,

and finally it requires follow-up on the ultimate performance of the material.

Quality control requires the services of a substantial metallurgical department. Many of the phases of the quality program are specifically the responsibility of this group, and improvements in practice are largely the result of keen and thoughtful analyses of statistical data and field observations by these men. Their efforts are of little value, however, without the enthusiastic cooperation of the operating people who must thoroughly understand the reasons for the various restrictive requirements. Without detracting in the least from the fine work of our metallurgical department, I am sure that our quality control program would not have attained its present degree of success without operator understanding, interest, and support.

Steel production problems emphasize, among other things, the need for close and accurate control of chemistry. Successfully meeting uniformly high-quality product requires not only close control of specified elements but also requires control of minor constituents, some of which are not covered by specifications.

Chemistry control must of necessity start with the ever-present elements, carbon and manganese. Substantial improvements in the control of these elements in the open hearth operation have resulted in an ability to meet a $\pm$ 0.02 per cent carbon range and a $\pm$ 0.10 per cent manganese range on low and medium carbon steels. Duquesne has not developed any innovations in melting practice that will guarantee complete control of all the complex reactions that influence addition efficiency, but rather the improved results can be attributed to meticulous adherence to every detail of the established melting practices. Production control has enabled melters to keep the percentage of heats meeting chemical specifications for these two elements at approximately 96 per cent of the heats melted. This type of control is essential to the Duquesne operation since the wide diversity of special products included in normal production schedules permits relatively little opportunity for diversion to other specifications.

The element, sulphur, presents a somewhat unusual problem at Duquesne. Since sulphur adversely affects hot working characteristics, surface, and cleanliness of most steels, it is desirable and even necessary in many instances to keep this element at the lowest possible level. At the same time, Duquesne produces fairly large tonnages of steel requiring sulphur additions for improved machinability. Current practices point toward the solution of these two widely different objectives by the use of a standardized melting practice pointed toward attainment of the lowest possible sulphur levels consistent with sound economics.

I presume that our plant is no different than many others with respect to difficulties encountered with purchased scrap. In 1953 and again in 1954 we conducted extensive experiments with bundled scrap, melting many seven-ton electric furnace heats from selected scrap shipments to determine metallic content, alloy contamination, and sulphur levels.

The results of these tests, which were released to the AISI and to the Scrap Institute, were surprising and definitely identified many of our melting problems with purchased scrap. While this information was not exactly news to the melt shop people, the quantitative results have served as a stimulus to the improvement of scrap quality. While we are far from satisfied with the current scrap quality, we do believe that there has been an improvement and that programs instituted by members of the Scrap Institute will ultimately result in substantial improvements.

Efforts in the direction of sulphur control still include reasonable selectivity with respect to scrap charged, usage of low sulphur fuels, and usage of iron which is somewhat unusual in chemistry. The Duquesne blast furnace practice appears to provide a good balance between uniform chemistry and economics. The practice involves substantial usage of open hearth slag, with tap and flush slags separated and used separately in the blast furnace burden. Slag used in this manner, and in quantities as high as 485 pounds per ton of iron, appears to have been helpful in removing sulphur. There has been in 1954 a steady decline in iron sulphur from an average level of about 0.040 per cent to a level of about 0.030 per cent. It is of interest, from an operating viewpoint, to note that this reduction was accomplished concurrently with reduced usage of coke and limestone.

Continued usage of large amounts of open hearth slag in the blast furnace burden has resulted in substantial increases in manganese and phosphorus. Apparently, however, a plant balance for these elements has been reached and manganese in the iron has leveled off at 2.5 to 3.0 per cent, while phosphorus seems to be stable between 0.280 and 0.300 per cent. The manganese in the iron may be helpful in controlling sulphur in the open hearth operation, although this conclusion is controversial. In any event, some portion of the manganese is recovered as increased residual manganese in the steel, and corresponding reductions in manganese additions are possible.

The phosphorus is an unavoidable penalty for the use of open hearth slag. It's presence emphasizes the need for close control of open hearth slag oxidation and basicity. The open hearth practice planned around this type of iron has been surprisingly successful in producing low sulphur steels. Melt and ladle sulphurs during recent periods with resulphurized heats eliminated from the data, show a low average sulphur level of 0.022 per cent, with many heats finishing between 0.015 and 0.018 per cent. This has been most helpful in reducing conditioning problems and in reducing finished-product rejections. The practice has also been adequate to cope with the phosphorus problem. Very substantial increases in the phosphorus content of the iron, have had no measurable effect upon phosphorus content of the steel produced from it.

While the importance of temperature control in melt shops has long been casually recognized, the necessity for controlling temperatures within narrow and restrictive limits has not always been so readily accepted. Accurate and dependable control has now been established as essential to the successful production of quality steels in open hearth and electric furnace shops

—control not only of tapping and pouring temperatures, but control of temperatures during various stages of the melting operation as well. By using immersion-type thermocouples to indicate and record bath temperatures, and as a result of a thorough understanding by all melting personnel of the importance of temperature control, Duquesne has been able to tap 80 per cent of all heats within a 30 F range. It is important to note that the remaining 20 per cent of the heats falling outside of this range are usually not very far out.

The work of Dr. Charles Herty and many other investigators has provided a valuable background of basic information for the guidance of the steel plant metallurgist in his effort to control consistently the amount of oxygen and the type, size, and frequency of oxides in steel. This information, incomplete though it may be at times, must be utilized to full advantage if a melt shop is to produce quality steels successfully.

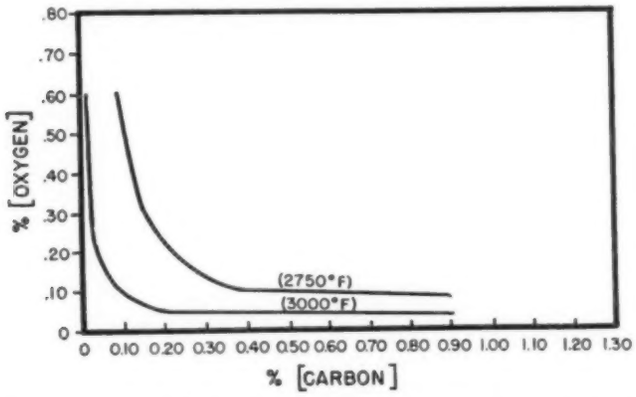


Figure 1 — One of the fundamental relationships in steel practice is the effect of bath temperature on equilibrium conditions for such ratios as per cent carbon vs per cent oxygen.

Oxygen content is important regardless of the type of melting operation, studies made by Dr. Charles Herty and associates show. Figure 1 shows the familiar oxygen-carbon equilibrium in liquid steel at two different temperatures. The curves show that higher bath temperatures result in lower oxygen content for any given carbon content, and many features of the Duquesne quality control make use of this well known relationship. Whereas the production of rimmed or capped steels requires a relatively high degree of oxidation of the steel bath, it is frequently necessary to maintain a low oxygen content in the interest of meeting close chemical specifications, in maintaining low sulphur contents, and particularly in controlling oxide inclusions.

The effectiveness of close oxygen control is illustrated by an example involving the production of stainless steels. These steels must meet minimum chromium requirements but upper limits are frequently determined by hot-working characteristics. Higher chromium heats with unsatisfactory chromium-nickel relationships are usually difficult to roll and in most instances result in abnormal material losses and high conditioning cost. For these reasons and in the interest of conserving chromium, it is important to control this element within the narrowest possible limits preferably in the band near the lower portion of the specification range. Such a practice entails the hazard of missing the objective on the low side and ending up with a heat that is out of specification.

Control of oxygen in the bath has materially reduced this hazard. The practice in this instance involves slagging off the oxidizing slag at the highest possible temperature level and at the highest possible carbon level consistent with the end product being melted in order to maintain low oxygen content in the bath. A marked decrease in the out-of-specification heats in 1953 and 1954 was obtained by the use of this practice plus the use of higher silicon residuals during the refining period. With silicon residuals of about 0.50 per cent, chromium recovery was high and uniform. The practice involves frequent and rapid silicon and chromium determinations which have been greatly facilitated by the use of a direct-reading spectrograph.

As previously stated, the oxygen level of the bath has a marked effect upon desulphurization by the slag. Since carbon is a major factor in controlling oxygen, it could be expected that the sulphur content in high carbon heats would be lower than the sulphur content in low carbon heats. However, it is possible to maintain low sulphur levels in low carbon heats by the use of silicon-bath deoxidation.

Although the nature and distribution of inclusions are influenced by the types of deoxidizers used, the actual quantity of oxide inclusions present is still a function of oxygen in the bath. As an illustration of the effect of oxygen content of the bath on cleanliness, we have reviewed a series of heats of AISI 4320 bearing quality steel and have found that an average of one heat in five did not meet the cleanliness standards for bearing quality when the bath was oxidized to correspond with a 0.12 per cent, or lower, carbon level. The successful solution to this problem involves mandatory slagging off at carbons above 0.12 per cent and diversion of the heats if they are oxidized below this point.

Control, of the type illustrated, has been most beneficial in improving cleanliness ratings of many grades of steel; it has resulted in improved performance of bearing steels; and it has helped materially in the improvement of physical properties where extreme stresses are encountered in fabrication.

Thus far we have discussed the quality control program in effect at Duquesne to assure production of internally sound steels. If the requirements of our customers could be satisfied by internal soundness alone, the job would be relatively simple. However, the buyers of shell, bearing, gear, and automotive steels also require product that is relatively free from external defects and which meets close dimensional and straightness tolerances. Such requirements necessitate the extension of a quality control program into all operations subsequent to melting, including ingot pouring, soaking pit heating, primary mill rolling, controlled cooling, conditioning, and even including the complex operations of secondary rolling and finishing departments.

Soaking pit operations have most significant effects upon steel surface. It is not possible to establish a universally applicable heating pattern since various types of steel require different treatment. However, in general, quality is favorably affected by minimum transit time and by minimum heating times that are consistent with the thermal characteristics of the steel being heated. A review of the wide diversity of products produced at Duquesne seems to point toward the low carbon alloy and the resulphurized grades as being the ones most sensitive to damage as the result of improper soaking pit practice. Ingot cracks, burnt steel, and seamy product are the inevitable results if careful controls are not maintained, if transit times are excessively long, or if heating times are too long or too short.

Heating and mill drafting practices at Duquesne are based upon finishing the rolling operation at prescribed temperatures.

Unfortunately, the various measures described in this paper, instead of eliminating the need for conditioning, have served only to minimize conditioning of blooms and billets. The successful production of blooms and billets for conversion into the products referred to in this paper requires more than superficial removal of visible defects—instead, it requires the removal of all defects. Conditioning practices must recognize differential product requirements and must be adapted to the ultimate end use of the product.

As in the primary mills, proper heating practices must be followed to insure sound bar product. Furnace atmosphere, heating time, and drawing temperatures must be specified for each grade to insure freedom from seams, pitting, and other surface defects. The adverse effect of inadequate heating time is shown by experience with the rolling of 1½ in. rounds from 4 x 4 billets when decreasing the heating time by 25 per cent causes marked deterioration in surface quality. This serves to illustrate the fact that maximum rolling rates are not necessarily controlled by mill speeds, but rather by available heating facilities.

No discussion of the production of quality steels would be complete without mention of the close controls required in heat treating and finishing those steels to meet customer requirements. Products encompassing the full range of H band and martensitic stainless steels require not only unerring control of heat treating practices, but further require extreme flexibility in that operation to compensate for minor chemistry variations.

The controlled practices described represent only highlights of an extremely complex program designed to produce the highest quality possible with available facilities and within the boundaries of present day metallurgical knowledge. Many other features of the program are equally important and none can be neglected.

Our quality control program at Duquesne uses as its theme, "Make It Right and It Will Be Right," and suggests the basic philosophy behind its operation. Increasing discards at the primary mill can, at times, improve etch-test experience; excessive conditioning can at times salvage substandard material; and critical inspection can sometimes improve the average quality of the product remaining after rejected bars have been removed, but none of these procedures is satisfactory from an economic standpoint. The Duquesne program involves diversion to less critical applications or even scrapping of product at the earliest possible point at which its successful processing becomes questionable. This somewhat drastic approach has proved to be sound from both metallurgical and economic standpoints and has saved much in terms of processing costs for questionable material. It has convinced us that product must be right at all stages of the operation, and that we cannot inspect quality into it if quality was not there in the first place.

1955 AISE

ANNUAL CONVENTION

SEPTEMBER 26, 27, 28, 29

HOTEL SHERMAN **CHICAGO, ILL.**

By E. I. POLLARD
Chief Electrical Engineer
Elliott Co.
Ridgway, Pa.

SYNCHRONOUS CONDENSERS for Steel Mill Service

. . . . the synchronous condenser, either alone or in combination with a buffer reactor or a series capacitor or both, can provide an effective method of keeping voltage flicker due to reactive load swings of an arc furnace within acceptable limits . . . . this problem will probably become more acute as additional electric furnace capacity is constructed . . . .

▲ THE use of synchronous condensers as sources of leading or lagging reactive kva for power factor correction and regulation of line voltage became rather extensive in the nineteen twenties. Since then, the static capacitor has been successfully developed and has proved to be a less expensive source of steady-state leading kva. Consequently capacitors have largely superseded condensers as a means of power factor correction.

Since the reactive kva delivered by a synchronous condenser to a system can be smoothly varied through its full leading and lagging range by control of field current, the condenser is much superior to the capacitor as a means of regulating line voltage. However, power systems have grown to the point where today capacitors in banks of 5000 kva, 10,000 kva or larger depending on the system, can be switched on and off as required by system load, without undue disturbance to voltage. Consequently the advantage enjoyed by the condenser of smooth control of the amount of reactive kva fed into the system has been largely nullified.

Switching of large banks of capacitors is not always done with impunity, however. Several years ago we received a complaint from a purchaser of a 2500-hp, 2300-volt, two-pole induction motor, to the effect that it occasionally emitted a peculiar noise described as a "grunt." Investigation disclosed that the noise occurred twice a day and coincided with the switching of a large bank of capacitors on the 33-kva circuit of the power company's substation several miles away. Further investigation by oscillograph showed that the noise resulted from a voltage surge of 200 per cent at the motor terminals lasting about 0.03 seconds and having a predominent component at about 500 cycles. Changes were made at the substation to reduce the surge caused by switching the capacitors, and the motor windings have not failed. Nevertheless it is disturbing to know that the motor, and other equipment in this plant, is being unintentionally hi-potted twice a day.

The condenser is capable of being operated underexcited to furnish lagging kva, as well as overexcited to furnish leading kva, and lagging kva available from the condenser is often nearly as valuable as leading kva when the machine is used as a means of voltage regulation.

While the synchronous machine has lost ground to the capacitor as a source of steady-state leading kva, its transient performance, that is, its performance during faults or when load is fluctuating rapidly, is beneficial, while the performance of a shunt capacitor is detrimental to the operation of the system. Sudden increase in low power factor lagging load results in a sudden voltage dip at the load, due to voltage drop through the line impedance. With the condenser located near the load, the sudden voltage dip at its terminals cause it suddenly to deliver more leading kva into the system, or stated differently, to absorb a portion of the sudden increase in lagging kva represented by the change in load. Thus the effect of the condenser is to reduce the amount of lagging kva drawn from the system through the line reactance and thereby reduce the magnitude of the voltage dip associated with the sudden increase in load. The converse is true if load is suddenly reduced.

On the other hand the current drawn by a shunt capacitor is proportional to the voltage across its terminals. A sudden voltage dip at its terminals causes it to feed less leading kva into the system and in effect

to suddenly increase the amount of lagging kva drawn through the line reactance, in addition to the increase in lagging kva associated with the sudden increase in load. The capacitor installed at the load, therefore, magnifies the voltage dip.

The principal uses of synchronous condensers today are those where the superior transient performance of the synchronous machine is of importance. One such use is on systems having long transmission lines, where the condenser is of great value in reducing the voltage dips during fault conditions. The inherent action of the condenser in feeding more leading kva into the system also contributes to the stability of the system during the fault.

Another similar application is use of a condenser to smooth out the voltage dips or "flicker" caused by the violent load fluctuations during the melting down period of a heat in an arc furnace. Condensers have been applied for this purpose more frequently in recent years. Competent authorities in the steel industry predict that arc furnaces will play an increasingly important part in the future in terms of proportion of total capacity produced by the various methods. It is, therefore, reasonable to expect that voltage flicker troubles will become more acute, and that synchronous condensers will be applied to alleviate these troubles in increasing numbers in the future.

THE ARC FURNACE FLICKER PROBLEM

Sudden short circuits occur between the electrodes of an arc furnace during the melting down period of the heat, and may be single phase or three phase. The resulting sudden short circuit currents are limited principally by the reactances of the furnace transformer and of the power system up to the furnace bus. These currents are of low power factor producing a voltage dip at the furnace bus, and at various other points on the power system depending on the reactance between those points and the source of generation. Duration of the short circuits varies widely, from as short as half cycle up to a second, many of them being of two or three cycles. Occurrences is quite frequent, several times a second. The magnitude of the short circuits vary, those most severe occurring less often. If voltage dips occurring so rapidly are of sufficient magnitude to be noticeable as "flicker" of an incandescent lamp, they are very annoying. Several years ago, a flicker of two volts on a 115 volt circuit, or 1.75 per cent, was considered by several authorities to be the maximum that would be tolerated by residential users of power. The advent of television has reduced this figure to something less than 1.5 per cent.

Residential or any other load that is critical from the standpoint of voltage flicker is referred to in this paper as the "critical load," and the critical load located nearest to the arc furnace bus in terms of system reactance X_S is the one to be considered in correcting flicker, as the magnitude of flicker varies in proportion to the line reactance between it and the source of generation.

Obviously, reduction of the voltage dip to acceptable limits can be accomplished by reducing system reactance, or by shunting a portion of the short circuit current to an additional source of generation of reactive kva.

Reduction of net system reactance can be obtained by means of a series capacitor located between the critical load and the system reactance X_S in Figure 1, in order to cancel out a portion of X_S, as reported by Jones, Arthur, Stearns and Johnson. This has several disadvantages. While it controls voltage flicker on the load side of its location on the system, it has no effect on other critical loads located on the generator side. It also has the disadvantage that no correction of furnace powerfactor is obtained.

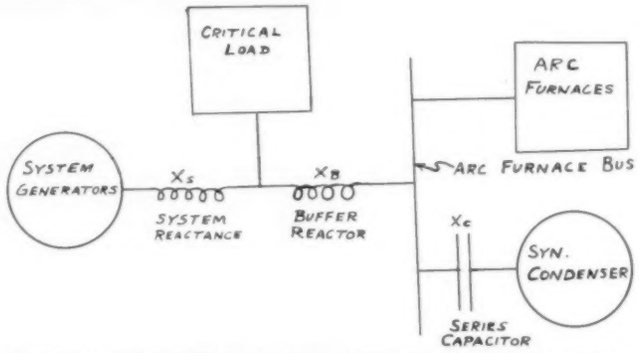


Figure 1 — Simplified system diagram shows scheme for controlling voltage flicker at load where flicker is critical. Reactances are per cent on base kva and equal equivalent 3-phase maximum sudden reactive kva change on furnace bus.

A synchronous condenser connected to the arc furnace bus acts as a parallel source of generation of reactive kva into which a portion of the sudden reactive load changes of the arc furnace can be shunted, the division of reactive being in inverse proportion to the reactances of the condenser, and from the furnace bus to the source of generation. Increasing the reactance between the furnace bus and the point of connection of the critical load by the addition of a buffer reactor diverts a greater portion of the sudden change of reactive kva to the condenser and thus reduces flicker at the critical load, in effect tending to isolate the arc furnace bus from the system. Addition of a series capacitor between the condenser and the furnace bus cancels a portion of the condenser reactance and accomplishes the same result. Expressed differently, a smaller condenser is required to limit the flicker to an acceptable value if a buffer reactor or a series capacitor, or both, are used in conjunction with it.

In order to compare the results obtained with various combinations of condenser, buffer reactor, capacitor in series with condenser, and system reactance, the data presented in Figures 2 to 5 were calculated, and is summarized in Figure 6 for a voltage dip of 1.5 per cent at the critical load. The calculations are based on a number of simplifying assumptions, the most important of which are as follows:

1. It is assumed that the system is resolved into the simple schematic diagram of Figure 1.
2. Line resistance and the kw component, of sudden furnace load change is neglected.
3. Calculations are based on the maximum 3-phase

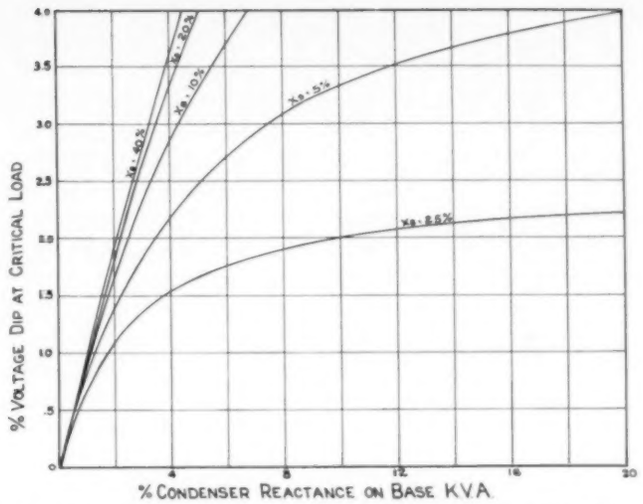


Figure 2 — Curves show condenser reactance required for various voltage dips when buffer reactance equals 0, $X_c=0$ and with system reactance X_s on base kva.

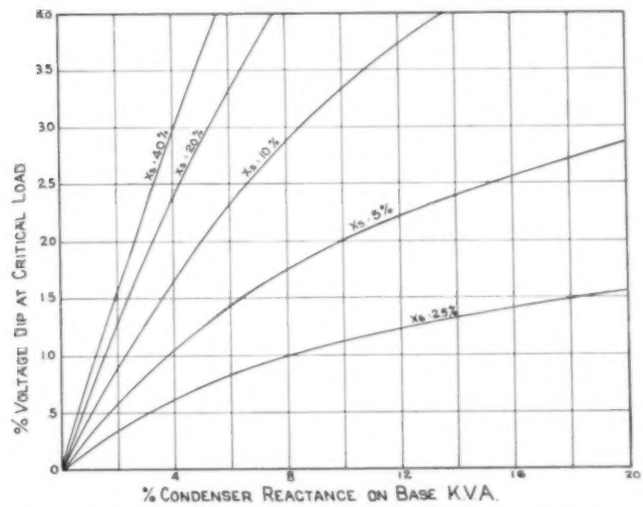


Figure 3 — Curves show per cent condenser reactance required for various per cent voltage dips with condenser and buffer reactor of 10 per cent on base kva and $X_c=0$.

sudden change in reactive kva on the furnace bus, which is the base kva to which all reactances are converted. Most of the short circuits within the furnace are single phase and it is assumed that the maximum single phase sudden kva change is converted to a 3-phase value which gives the same voltage flicker at the critical load. Since the behavior of the furnace is quite complex and follows no cylical repetitive pattern, choice of the correct base kva is difficult and requires careful study of the performance of the furnace during the melting down period, as well as good judgment. Since a fixed kva change is assumed, the reactance of the furnace and its transformers is neglected. Base kva is, therefore, the value existing after taking into account the effect of adding the condenser and associated equipment.

4. Condenser stability is not considered, and this may determine the maximum size of buffer reactor that can be applied.
5. Voltage regulation on the furnace bus is not con-

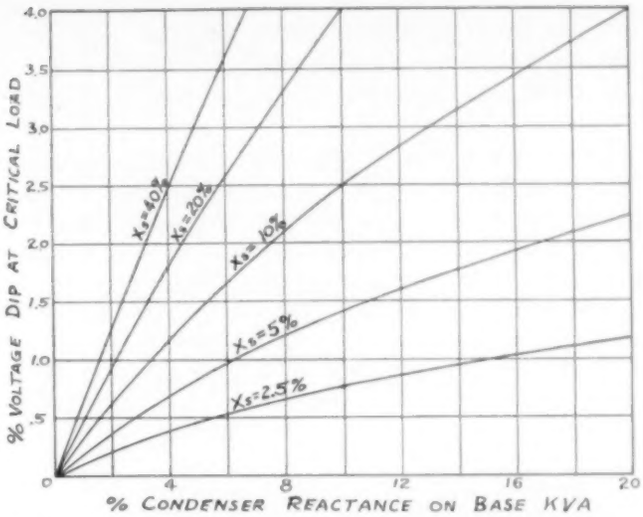


Figure 4 — Curves show per cent condenser reactance required for various per cent voltage dips for condenser and buffer reactor of 20 per cent on base kva and base $X_c=0$.

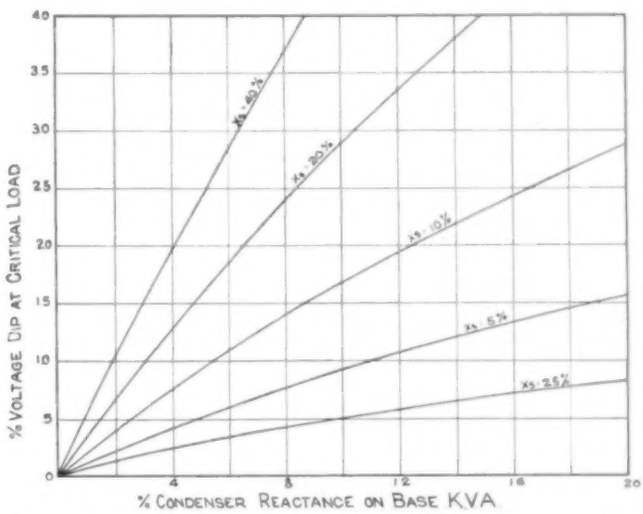
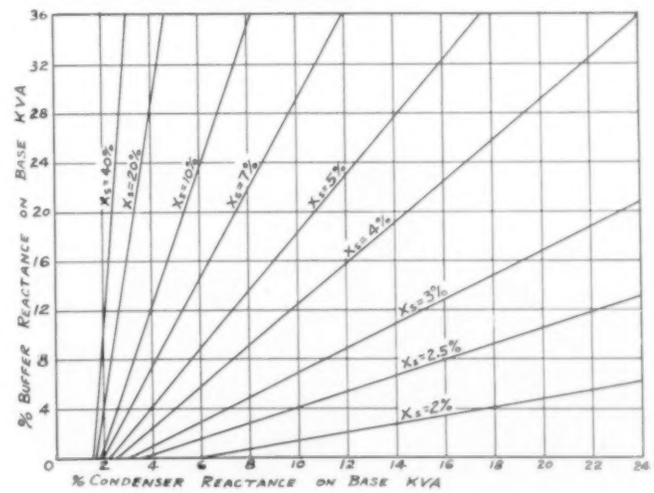


Figure 5 — Curves show per cent condenser reactance required for various per cent voltage dips for condenser and buffer reactor of 40 per cent on base kva and $X_c=0$.

Figure 6 — Curves show buffer reactance for various condenser reactances required to obtain a voltage dip of 1.5 per cent at critical loads.



sidered, and this may determine the maximum size of buffer reactor that can be applied.

6. Sudden reactive kva contribution by the critical load itself, due to the sudden voltage dip, is neglected.

The curves of Figures 2 to 6 are presented as an illustration of the effects of varying the buffer and condenser reactances, and as a preliminary solution of the condenser application problem. They are not intended to represent a complete solution of the problem.

The voltage dip at the furnace bus is equal to the combined value of the condenser reactance in parallel with $X_S + X_B$. The voltage dip at the critical load is equal to the dip at the furnace bus multiplied by $X_S/(X_S + X_B)$. The equation of Figures 2 to 5 is:

$$\text{Voltage Dip at Critical Load} = \frac{X_S}{X_S + X_B} \times \frac{1}{\frac{1}{X_S + X_B} + \frac{1}{\text{Condenser Reactance}}}$$

in which the reactances and voltage dip are in per unit instead of per cent.

From this equation it is apparent that the value of condenser reactance required to obtain a given value of voltage dip varies as $X_S + X_B$. For example, if a buffer reactance of $X_B = X_S$ is used, the condenser reactance required for a given voltage dip is twice the value required if no buffer reactor is used, that is, the size of condenser required is reduced to one-half.

The effect of adding a series capacitor between the condenser and the furnace bus is to cancel a portion of the condenser reactance, causing it to absorb a greater proportion of the sudden change in load and making it possible to use a smaller condenser. If the reactance of the series capacitor is equal to one-half of the condenser reactance, the size of condenser required to obtain a given voltage dip is reduced to one-half the size required if no series capacitor is used. Addition of a series capacitor brings up additional problems. Since much of the subtransient reactance of the condenser is cancelled by the capacitor, a short circuit on the furnace bus would result in excessive short circuit current in the condenser. Protection against this is obtained by shunting the capacitor with a spark gap set to break down and short the capacitor out of the circuit at a safe value of current, say at about twice the rated current of the condenser. The gap itself is protected by a contactor arranged to divert current from the gap immediately after it has broken down, and which serves as a means of reinserting the capacitors in the circuit after current has been restored to a safe value. A resistor shunting the capacitor is also required to provide positive damping of the low frequency transients encountered.

While addition of a series capacitor makes possible a marked reduction in the size of condenser required to reduce the voltage flicker to a given value, the economical size of condenser also depends upon other factors such as correction of furnace power factor and voltage regulation on the arc furnace bus. Consequently installation of a series capacitor and its associated equipment is not necessarily justified economically.

TYPICAL INSTALLATION

A typical installation serves two sixty-ton arc furnaces which are estimated to have a sudden load change equivalent to 19,000 kva, 3 phase. On this base, the system reactance X_S is 5.6 per cent. Reactance from the critical load to the arc furnace bus is 12.6 per cent and acts as a buffer reactor, and an additional buffer reactor of 19 per cent was provided. The rated voltage value of the 20,000-kva condenser transient reactance reduced to allow for operation at partial load is 21.8 per cent on base kva. The reactance of the capacitor in series with the condenser is 11 per cent. The calculated flicker at the critical load, and at other loads at the steel mill, for various combinations of corrective equipment, are as follows:

	Calculated voltage flicker, per cent	
	At critical load	At other mill loads
With no corrective equipment	5.6	18.2
With condenser only	3.1	10.0
With condenser and buffer reactor	2.1	6.7
With condenser, buffer reactor, and series capacitor	1.3	4.1

In order to accomplish the 1.3 per cent flicker obtained at the critical load without the use of a series capacitor, a condenser of twice the rating would have been required. If the buffer reactor were also omitted, a condenser of four times the rating would have been required.

CONDENSER REACTANCE

Direct axis synchronous machine reactances are defined in AIEE No. 503, depending on the rapidity of the change of current after a sudden change in load is applied. At the instant of sudden load change, the subtransient reactance applies, and determines the initial magnitude of voltage dip at the condenser terminals. The reactance then increases very rapidly, in from 2 to 6 cycles, depending primarily on the design of the cage winding, to a value equal to the transient reactance, which determines the voltage dip at the machine terminals after 2 to 6 cycles have elapsed. After this the reactance increases slowly to a value equal to the synchronous reactions, which determines the steady state voltage after all transient effects are over.

Many of the sudden reactive load changes in arc furnaces are of only one-half cycle or one cycle duration, and use of the subtransient reactance of the condenser yields an accurate value for the voltage dip resulting from them. However, the behavior of an arc furnace during the melting down period is very erratic. As well as load changes of very short duration, those of longer duration in the range of 4 to 8 cycles, while not occurring so often, occur frequently enough to require consideration, and the transient reactance gives a more accurate value for the voltage dips resulting from them. For loads of much longer duration, the

voltage dips will not appreciably exceed the value calculated using the transient reactance of the condenser provided the excitation system is reasonably fast.

The magnitude of synchronous machine reactances is affected by saturation, and diminish as the flux in the machine is increased. Tests made by suddenly applying large reactive loads from no load on a 50,000-kva synchronous condenser show that saturated, that is, rated voltage values of transient and subtransient reactances give accurate results when used to calculate voltage dips. However, an economical application of a condenser to an arc furnace load would involve using at least half of its corrective capacity. It would not be normally operated at no load, but at at least half load over-excited. For this condition, the flux in the machine is 10 to 15 per cent higher than at no load. Due to the additional saturation, the subtransient and particularly the transient reactances are lower than the values determined by a sudden short circuit test at rated voltage.

Considering all of these factors, it is recommended that a reactance equal to 0.9 of the rated voltage value of the transient reactance be used in applying a condenser to an arc furnace.

Standard air-cooled synchronous condensers have a lagging capacity of 50 per cent of their leading rating, and have the following approximate per cent reactances:

Number of poles	18	10	12 or 14
Unsaturated transient (rated current value), X'_{du}	45	48	50
Saturated transient (rated voltage value), X'_d	40	43	45
Subtransient, X''_d	26	28	29
Unsaturated synchronous	217	217	217

The approximate reactances of standard hydrogen-cooled condensers rated at ½ psig hydrogen pressure are 1.2 times the above values, and have a lagging capacity of 42 per cent of their leading rating.

When lower reactances are required, they may be obtained by use of an oversize standard machine, or a machine specially designed for low reactance. In the latter case, the machine is worked higher in flux and lower in ampere-conductors than the standard machine, and the electrical design proportions are modified, in order to reduce reactance. As a result, the physical size of the machine need be increased less in order to arrive at a given reduction in reactance than would be required if an oversize condenser of standard design were used. Consequently, the special condenser is less costly to manufacture. However, this advantage may be offset by the additional cost of designing and tooling the special machine.

DESIGN FEATURES FOR ARC FURNACE SERVICE

Negative sequence line currents resulting from the large proportion of single phase short circuits within the arc furnace during the meltdown period are reflected in the squirrel cage winding in the pole faces, and consequent heating of the cage winding should be considered. The bars should be ample in cross section and of low resistivity material such as copper. While this reduces the starting torque per ampere of inrush current, conservatism in heating of the cage winding during operation is more to be desired than superior starting performance.

Since the condenser is subjected to severe and frequent load swings, particularly if a series capacitor is used, the bracing of the stator end windings should be more robust than for a machine subjected to normal load conditions.

While the machine is subjected to severe electrical load swings, its mechanical load is zero, so unusual mechanical loads are not imposed upon it, as for other steel mill rotating machinery such as main roll drives. Consequently, its mechanical design need be no more rugged than for any other condenser application. Air-cooled condensers should be totally-enclosed and equipped with coolers in the interest of cleanliness and reduced maintenance.

The speed of response of the excitation system need not be particularly high, as most of the reactive load swings are of such short duration that the effect of

Figure 7 — This 20,000-kva, air-cooled, synchronous condenser of low reactance design serves arc furnaces in a midwestern steel mill.

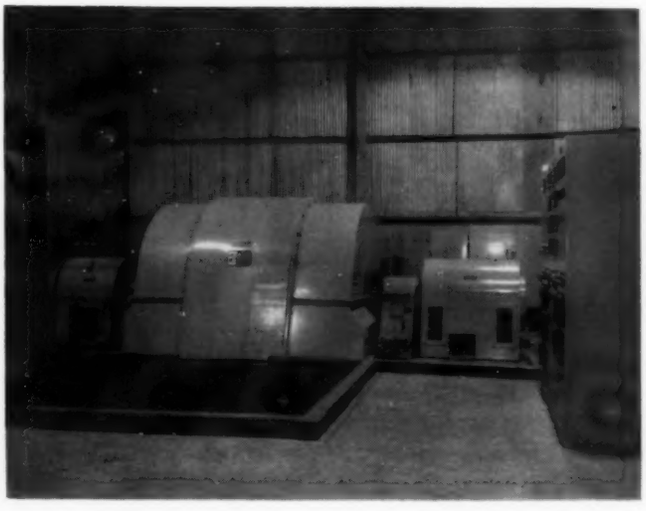
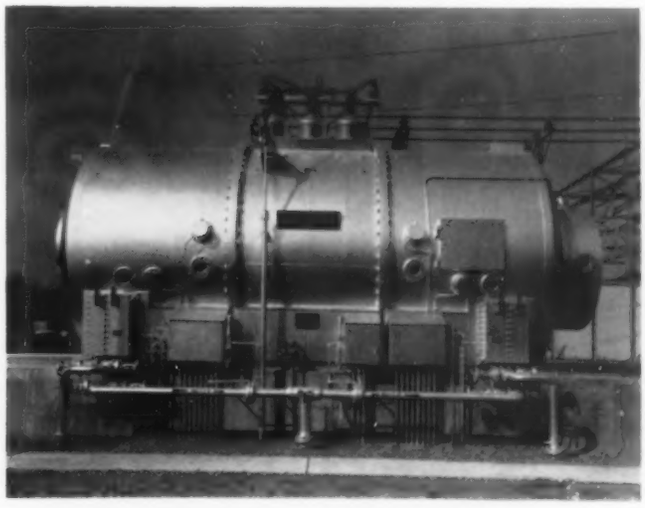


Figure 8 — This 50,000-kva, hydrogen cooled synchronous condenser of low reactance design is suitable for steel mill service.



exciter response in limiting voltage flicker is negligible.

The voltage regulator should not be of the contact-making type such as the rheostatic indirect-acting regulator. Load is changing so rapidly that such a regulator would tend to continually shift rheostat position resulting in excessive maintenance. Regulators of the electronic, rotary amplifier or magnetic amplifier types do not have this disadvantage.

HYDROGEN-COOLING

The superior heat transfer properties of hydrogen compared with air as a coolant make possible an increase in rating of 20 per cent when a condenser is operated in hydrogen at atmospheric pressure. A further gain of 25 per cent in output is possible when the gas pressure is raised to 30 psig. The enclosing structure is made strong enough to resist the explosion pressure corresponding to the most unfavorable mixture of air and hydrogen without causing external damage to the machine. Since the structure is gas-tight, the machine is inherently suitable for outdoor service. The increased cost of this structure together with that of the necessary gas control equipment offsets some of the advantage of the increased capacity resulting from hydrogen cooling. Based on cost per kva at the 30 psig capability, the hydrogen-cooled machine is less expensive than the outdoor type air-cooled condenser with coolers, and is less expensive than the indoor-type air-cooled condenser with coolers above about 25,000 kva. The principal disadvantage of hydrogen-cooled condensers for arc furnace service is their reactances are 20 per cent higher than for air-cooled machines based on the one-half psig rating, and 50 per cent higher based on their 30 psig capability. For the same per cent reactance, hydrogen-cooled condensers cost more per kva.

Losses of hydrogen-cooled condensers are less than for air-cooled machines, due to the low density of hydrogen resulting in much lower windage loss. Other advantages of hydrogen-cooling are elimination of dirt from external sources, and reduced deterioration of insulation due to corona. Both of these advantages result in longer winding life and reduced maintenance.

SUMMARY

The synchronous condenser, alone or in combination with a buffer reactor or a series capacitor or both, provides an effective method of keeping voltage flicker due to the reactive load swings of an arc furnace within acceptable limits. Growth in the size of arc furnaces and the trend toward this method of producing steel indicates that this problem will become more acute in the future, and that condensers will be applied as a solution more often than in the past. For example, we recently delivered a 30,000-kva air-cooled condenser to the Bethlehem Steel Corp. for arc furnace service. Another example is the purchase of four 50,000-kva hydrogen-cooled condensers by the Detroit Edison Co. for arc furnace service, including two 150-ton furnaces at McLouth Steel.

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DISCUSSION

PRESENTED BY

L. G. LEVOY, Power Systems Engineer, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

E. I. POLLARD, Chief Electrical Engineer, Elliott Co., Ridgway, Pa.

L. G. Levoy: Mr. Pollard has presented an interesting and timely paper. I think that we can look forward to the future of arc furnaces on electric systems with a great deal of confidence. It should be noted that there are many arc furnaces in operation where it has not been necessary to use a synchronous condenser. The use of a synchronous condenser in any particular application depends upon a number of factors that should be considered carefully.

One of these factors is that as more arc furnaces are placed in a particular area or on a particular bus for that matter, the flicker voltages from the several arc furnaces do not add arithmetically because the flicker voltage from each furnace is aperiodic or random in nature. For example, tests indicate that two equal size arc furnaces operated from a given bus produce a flicker voltage of only about 1.2 times the flicker voltage which one furnace acting alone would cause. Likewise three equal size arc furnaces would produce a flicker voltage of about 1.3 times that of a single furnace. Thus as the number of furnaces becomes larger, the diversity factor in effect on the flickers tends to smooth out the total load rather than to aggravate its roughness. This is one helpful factor in supplying more arc furnace load from utility systems.

Another factor is, that as more and more arc furnaces are supplied from the system, it inherently becomes necessary to provide a larger and heavier system to serve them and the other loads that they usually bring with them.

Often it is economical to reinforce the power system, or serve the arc furnaces from a higher voltage level at a place in the system where the short circuit level

is sufficiently high to accept the flicker load without producing objectionable flicker voltage.

I would like to comment briefly on the use of series capacitors in connection with synchronous condensers to make the synchronous condenser look larger. It is true that the presence of a series capacitor decreases both the transient and subtransient reactance of a combination series capacitor-condenser circuit. With such a connection, the series capacitor will be subjected to suddenly imposed loads from the arc furnace. This transient loading results in voltage transients across the capacitor which may be several times the steady state value for sustained loads of the same magnitude. The capacitor must, therefore, be built to withstand this transient voltage, or alternatively it must be taken out of service by a protective gap and re-inserted in the circuit after the transient has been reduced to a safe value.

If the capacitor is built to withstand the crest transient voltage to which it may be subjected it will be very expensive. It is switched out of the circuit on the largest flicker peaks, it is not there when it is needed most. For these reasons, and particularly for new installations, we would normally consider using a larger condenser rather than a combination of a series capacitor with a smaller condenser.

I would like to ask Mr. Pollard whether or not he has investigated the amount of buffer reactance which is allowable? Buffer reactance is inexpensive compared with synchronous condenser kva. There is of course a limit as to how high the buffer reactance can be made in any given case because if made too high it will not be possible to maintain voltage and production on the arc furnaces, and also the condenser may fall out of step with the system when sudden load changes occur in the furnaces.

E. I. Pollard: We agree that the use of a capacitor in series with a synchronous condenser presents some problems regarding the design and application of the capacitor which must be solved in order for the installation to be successful.

Mr. Levoy inquires whether we have investigated the maximum amount of buffer reactance allowable from the standpoint of stability, before hunting of the condenser becomes too violent as pull-out of the condenser from the system is approached.

A discussion of the stability of an installation of this type, and a method of determining whether stability can be achieved is given in the paper by R. L. Witzke and E. L. Michelson (Reference 5). It is possible that broad assumptions could be made regarding the magnitude and period of the arc furnace load swings, and the stability characteristics of the condenser and the system, and calculate the general relationship between the maximum buffer reactance and the various components of the system indicated on Figure 1. We have not made such calculations, as it appears that the assumptions would necessarily be so broad that the results would be of doubtful value.

Satisfactory stability was achieved in the typical installation referred to in this paper for operation either with or without the series capacitor in service. In this instance the effective buffer reactance is 44.3 per cent referred to rated kva of the condenser. Stability is reported by T. G. LeClair (Reference 2) in an installation in which a buffer reactance of 24 per cent based on condenser rated kva was used, but a buffer reactance of 44 per cent resulted in unstable operation. However, it should be noted that the system reactance was nearly double and the inherent stability of the condenser probably somewhat less than for the typical installation cited in this paper.

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VACUUM FURNACES WILL MAKE BETTER STEELS

▲ THE new semi-continuous, 1000-lb vacuum melting furnace placed in operation at Carboloy Department of General Electric Co., Detroit, on May 24, represents another step in alleviating metallurgical problems which have been creating a bottleneck at the designers' level.

By adding better than 60 tons per month of specialized vacuum melted alloys to the nation's capacity, the new pilot production unit will provide designers a little more leeway in selecting better materials for advanced development work, will make it possible to create entirely new alloys from lower-cost, less critical elements of equal or better structural properties than those produced by air melting.

The additional capacity also will help relieve the pressure on metallurgists who have been hindered by three basic problems—that of controlling elements such as oxygen and nitrogen, of limitations in adding alloying elements, and the problem of getting rid of dissolved gases and impurities—all associated with conventional air melting.

For the nation's industry in general, the availability of metals of longer life from vacuum or controlled atmosphere process, means a reduction in the maintenance bill due to bearing and other failures on industrial equipment.

Greatest uses currently for vacuum melted alloys are in the gas turbine field—for aircraft, locomotives, stationary power plants, etc., and in the airframe industry for such items as landing gears and aircraft struts.

In other areas, such metals enable designers to break loose developments now bottlenecked on drawing boards because of unavailable, or strategic materials. One example is the gas turbine auto power package, which to date exists only in the form of experimental models due to the use of high cost or strategic materials.

The new installation, along with the others currently in operation in the country, also places at the users' disposal more metals alloyed with sizeable percentages of elements such as titanium and zirconium which cannot be added in any appreciable amounts in conventional open hearth and electric furnace practices.

What happens when you melt metals in a vacuum? Simply that the metals and alloys are produced essentially free of inclusions or impurities and with closer composition control. The metals are melted with considerably less loss of their critical alloying elements through either oxidation or through undesirable side reactions that often occur in conventional practices.

Built by Consolidated Vacuum Corp., Rochester, N. Y., it is of the so-called modular type. This means it is designed so its operation can be expanded or curtailed, much on the order of building blocks.

By providing various chamber bottoms with suitable accessory equipment, single ingots, multiple-

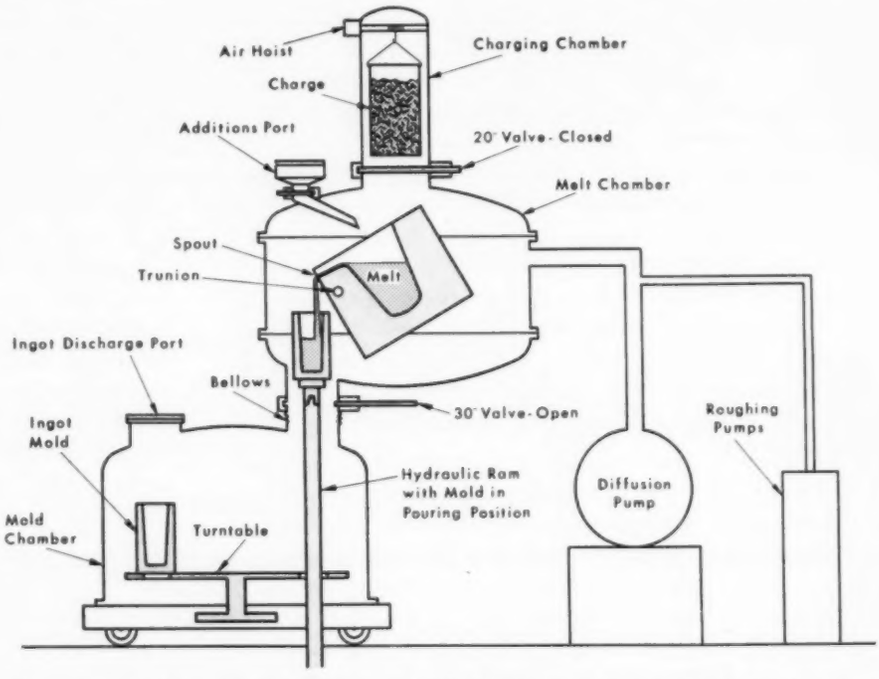

Figure 1 — Schematic shows new 1000-lb vacuum furnace installation at Carboloy Dept. of General Electric Co., Detroit. Note how ingot mold is positioned for pouring, and how other ingot molds are indexed on turntable.

In some instances, the process fosters the development and production of a completely new family of metals and their alloys. For many existing alloys, melting in a vacuum so markedly improves their mechanical properties that these too could be classed as new alloys.

The new 1000-lb furnace at Carboloy Department is typical of an installation that not only provides flexibility of operation, but also lends itself to expanded capacity. At present, it is capable of producing two 1000-lb heats per shift.

shaped castings or centrifugal castings can be produced from the same furnace. Semi-continuous operation is provided by interlocks through which the crucible can be charged, the alloying elements altered and the ingots removed without breaking the vacuum in the main chamber.

The semi-continuous vacuum melting unit at Carboloy basically is made up of three systems tied into one package. These are so inter-related that it is entirely possible for one operator to handle the main furnace and auxiliary operations. But for

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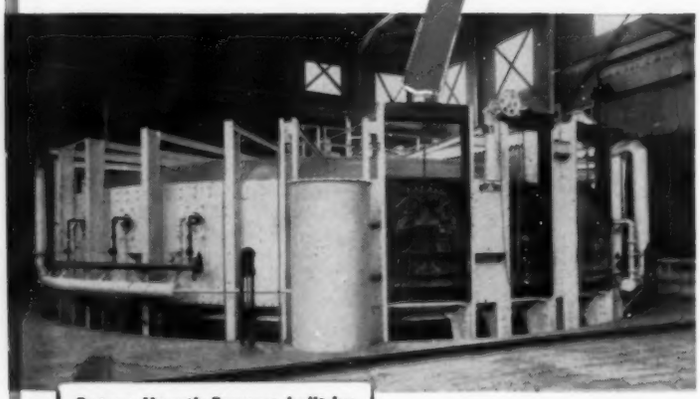

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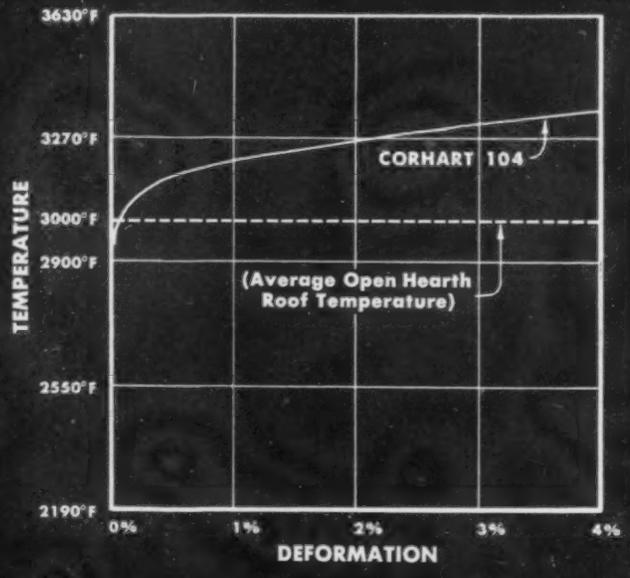

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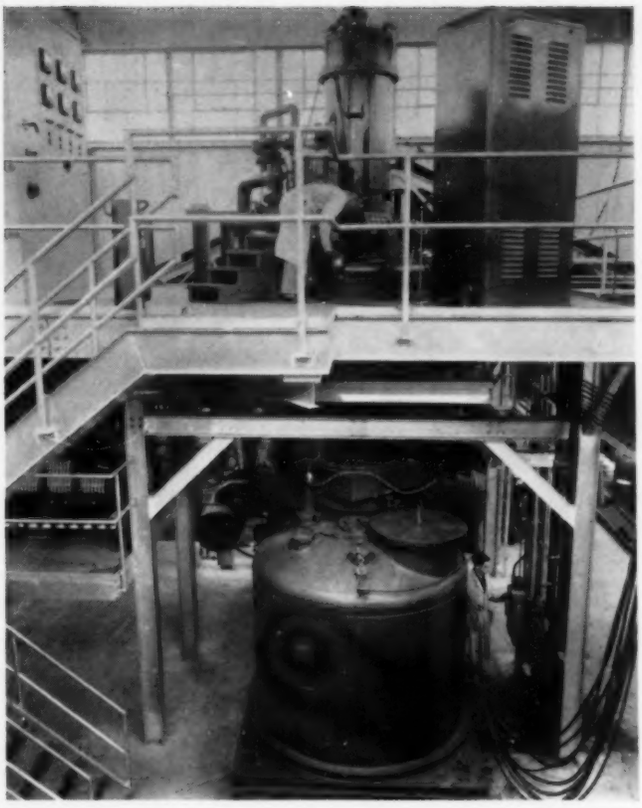


Figure 2 — Overall view shows new 1000-lb vacuum melting installation which will add more than 120,000 lb of vacuum melted alloys to the nation's capacity. It is capable of producing two 1000-lb heats per shift.

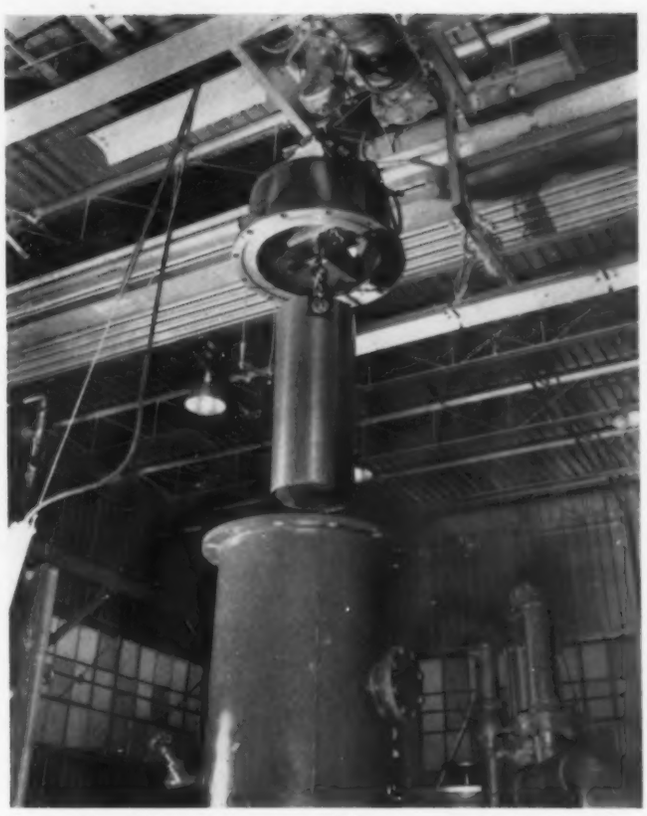


Figure 3 — Charging can is being lowered into charging chamber. Cover is then sealed and charging chamber evacuated of air. When proper pressure is reached, valve between charging chamber and main furnace is opened, and charge lowered into furnace crucible.

efficiency and safety reasons, two attendants are the normal practice.

What makes this centralized control possible is the use of three control panels. These coordinate all functions of the power and the air evacuating systems with those of the furnace itself.

One panel is used strictly for power to balance out the capacitor banks of the 350-kva motor-generator set supplying power for induction heating. The second panel is used to control the vacuum system. Unusual feature of this panel is that it includes a schematic diagram of the vacuum lines tied in with indicating lights, so that the operator knows exactly what is happening at all times. The panel lends considerable flexibility to the system since it can be used to control, or shut off any section of the vacuum system when necessary.

Smallest of the control panels is used to index the turntable on which the ingot molds rest, and also the mechanism that raises the ingot molds up into the main section of the furnace chamber for pouring.

Figure 4 — Metal in the furnace crucible is liquified in about an hour with temperatures ranging from 2800 to 3200 F. Operator here is shown using a bridge breaker inserted in special port to break loose crusting action.

Figure 5 — When heat is ready for pouring, a bell-shaped chamber containing ingot molds is wheeled directly under 30-in. valve of main furnace chamber as shown. Bellows type flange facilitates making air-tight connection.

Three pumps are included in the air evacuating system, two roughing pumps and an oil diffusion pump. All of these can be operated simultaneously or individually. Of the two roughing pumping systems, the 500-cu ft Kinney is capable of handling the furnace operation alone. However, the addition of a 300-cu ft unit gives the furnace added efficiency and speed, and is used mostly for expelling air from various chambers as the operations demand.

Extremely low pressures are obtained with a third pump—an oil diffusion, 3-stage unit. Where the roughing pumps will get down to pressures of around 500 microns, the oil diffusion pump will take the pressure down to less than one micron.

The control panel as well as other operating equipment are all located near the top of the furnace. Here also are found fixtures for an immersion thermocouple for controlling pouring temperature, sampling device and equipment for inserting certain working tools into the furnace as necessary.

The induction furnace used for melting is mounted on a trunnion inside a stainless steel tank. Interesting feature here is that power is introduced to the furnace by means of a co-axial arrangement, eliminating the use of flexible leads. Also electrical contact is made by means of shoe-type contacts which are air actuated. These clamp onto the co-axial cable when power is needed. The cable, incidentally, also is water cooled.

Two levers are used to control the induction furnace. One is employed to cut off power and disengage locking pins, the other to tilt the induction furnace through a hydraulic system.

In getting the furnace ready for a typical vacuum melt, a lining or crucible is placed in the induction furnace. Charging then is done with special containers about the size of a garbage can. The containers are filled with the desired metallic elements for the melt in predetermined amounts until the can is filled.

Since the can also is melted during the heat, the container can be selected in accordance with what it can contribute to the analysis of the melt. If an appreciable iron content is permitted, for example, an iron container can be used or, if iron is not desired, a nickel or other applicable container is selected.

Figure 6 — Panel shown controls any section of the vacuum system. It includes a schematic diagram of all vacuum lines tied in with indicating lights. This enables furnace operator to know exactly what is happening at all times. Separate control panel is used to balance out capacitor banks of 350-kva motor-generator set supplying power to the induction furnace.

After the container is filled, it is lifted to the top of the vacuum melting furnace and hooked on the inside top cover which is in a raised position. The cover is then replaced, and a windlass arrangement lowers the charge in the charging chamber. At this point, the charging chamber is sealed and a roughing pump evacuates the air from the chamber.

When the pressure is down sufficiently, a matter of minutes, a pneumatically-operated, sliding valve under the chamber is opened, and the charge continues its descent, and is positioned in the crucible of the induction furnace. The hook is then disengaged, hoisted out of the way, and the valve closed off.

Once the melt starts, the charging chamber can again be readied with a second charge. Melting, which ranges in temperatures between 2800 to 3200 F, takes about one hour. Total cycle, including refining requires about five hours.

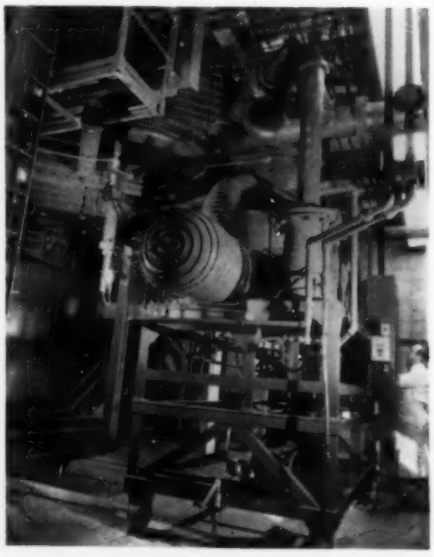
As melting continues, the original charge shrinks so that it is necessary to make additional bulk additions to bring the heat up to capacity. Additions are made through a separate, valved off charging lock. Like the main charging chamber, after the additions are made, it is roughed out by a pump and, when the pressure is down, the charge is dropped onto a vibratory chute leading to the furnace.

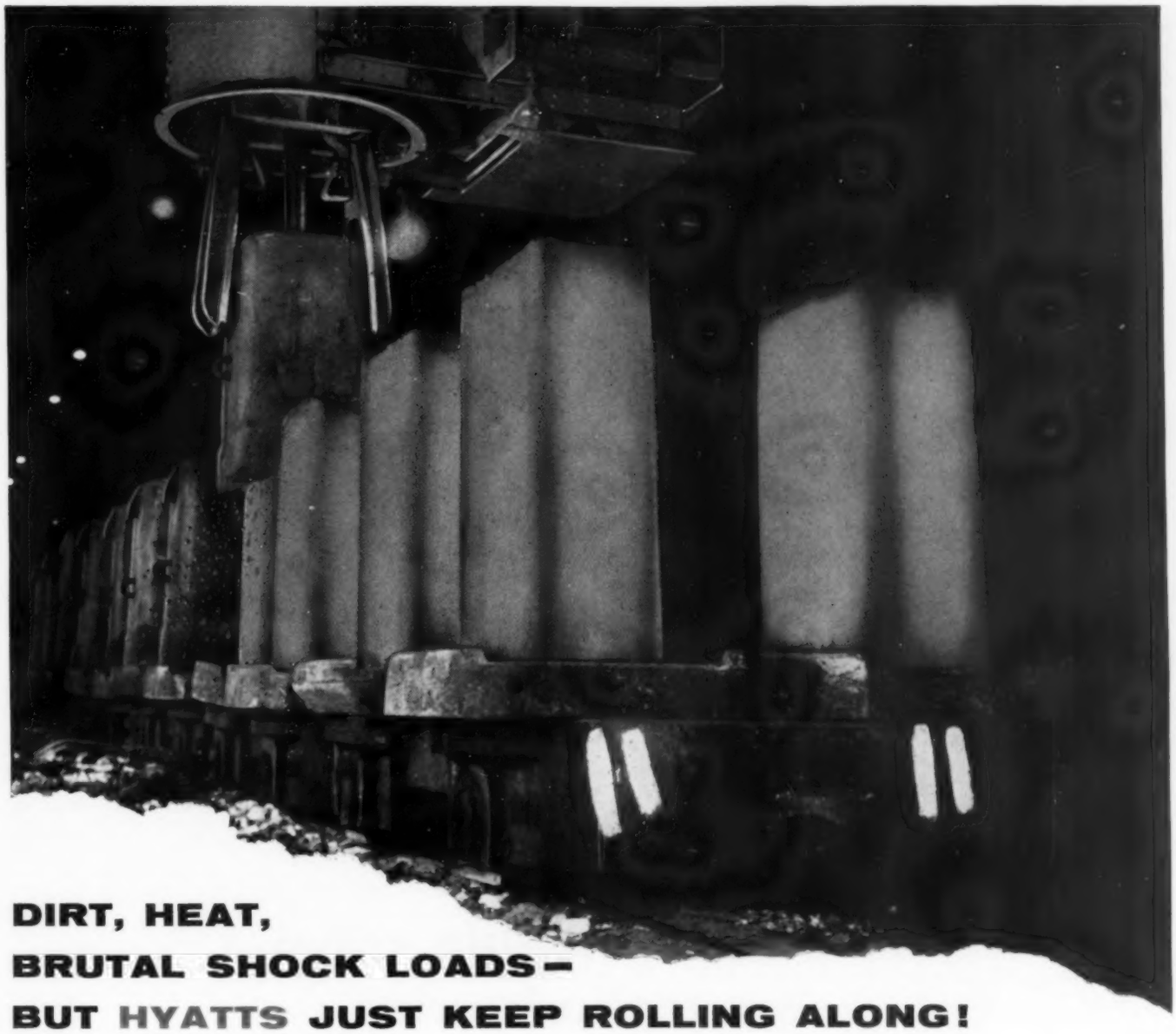
Ingot molds for pouring are located in a large bell-shaped container mounted on a platform that runs on tracks. Molds themselves rest on a turntable which forms the bottom of the huge container or jar. At pouring time, the huge jar is pushed into position and spotted under a 30-in. valve. Then through a bellows arrangement on top of the jar the flange is raised to meet the 30-in. valve.

After the connection is sealed, and the huge jar is evacuated by a roughing pump, the 30-in. valve leading to the induction furnace is then opened and the turntable in the huge bell jar indexes a mold into position. A filling station type lift is employed to lift the mold through the valve into pouring position in the main chamber of the vacuum furnace. After pouring the hot ingot is then lowered into the bell jar, and the operation is repeated by indexing the turntable.

Heats in the Carboloy unit can be divided into as many as six ingots, before it is necessary to disengage the ingot platform. The latter handles molds for any size ingot ranging from 100 to 1000 lb.

Figure 7 — Three pumps are used to evacuate air from new Carboloy vacuum melting installation. Diffusion pump here enables pressure to be dropped to less than one micron.





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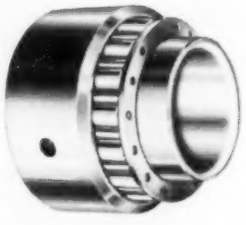

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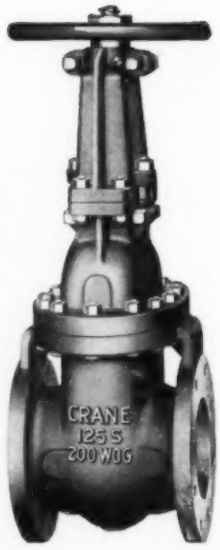

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Lime Treatment Removes Iron from Process Water

By W. W. ARMSTRONG and H. E. CASE
Machinery Division
Dravo Corp.
Pittsburgh, Pa.

▲ RECURRING piping maintenance problems and intolerable incrustations in its process water distribution system, together with an ever increasing need for more water, convinced engineers at the Universal Cyclops Steel Co., Bridgeville, Pa., that it was time to find a remedy for both troubles. After completing a thorough survey of the situation, through The Chester Engineers, they contracted with Dravo Corp. for a new water clarification plant.

Production at Universal Cyclops is devoted mostly to tool steels, high alloy and other special purpose steels throughout the world. The third largest producer of specialty steels, it turns out more than 500 different grades of tailored steels for uses ranging from wrist watch bands to giant industrial cutting tools. Cooling water is a necessary service in such an operation.

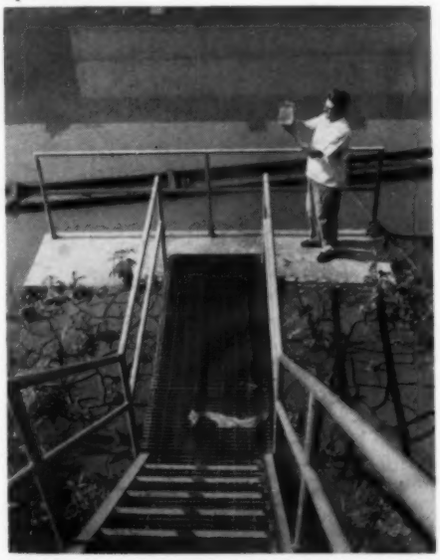


Figure 1 — Heavy mud deposit at the intake of the Universal Cyclops water treatment plant indicates the heavy silt load carried by Chartiers Creek.

Raw water for the Bridgeville plant comes from Chartiers creek, a small stream which carries the run-off from surrounding farm land as well as mine drainage, industrial waste and raw sewage. Consequently, it is highly turbid at times, and always contains a large amount of iron in solution together with a considerable amount of iron bacteria. The water's pH ranges from 3.5 to 7.5.

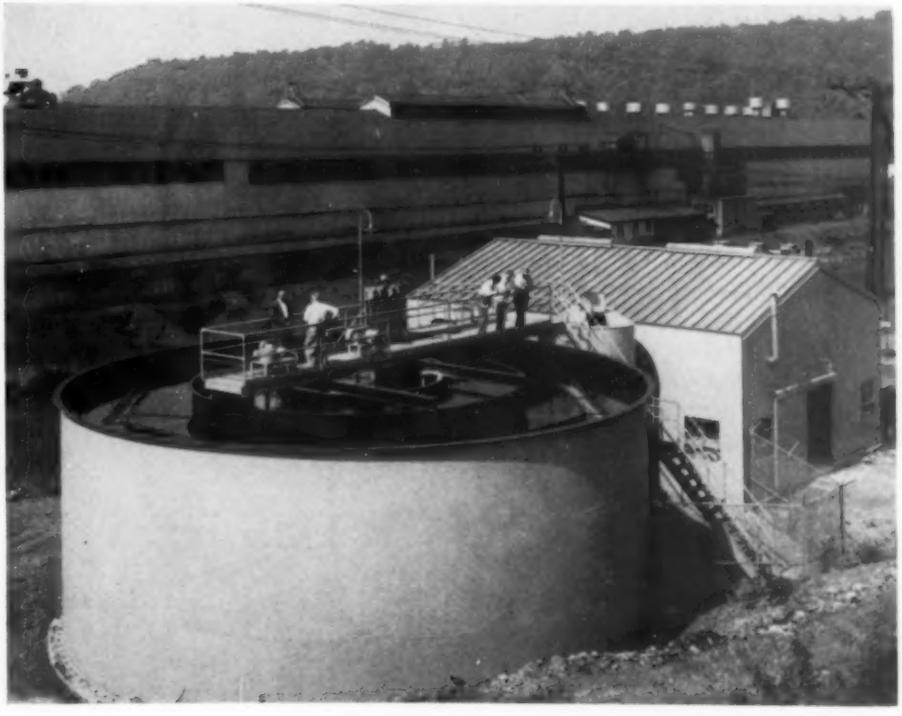
Since the original treatment consisted only of passing the water through five 150-gpm pressure sand filters, the distribution piping was always becoming obstructed by iron and crenothrix deposits. Thus, it was necessary to replace piping frequently to keep the required amount of water flowing. Furthermore, the filters could not meet the increasing demands and more and more water had to be purchased from an outside source at considerable cost to backwash and clean the filters.

Plant water is used to cool five electric furnaces and several rolling mills as well as to serve numerous miscellaneous needs. Each of the furnaces requires about 600 gpm, all of which discharges into a collecting tank. From here, two pumps, 150 and 450-gpm units, take the water and return it to the distribution system downstream from the furnace supply. Plant use is about 1,000,000 gal per day, 722,000 of which come from the main source, with the remainder being recirculated from the furnaces.

To meet this demand and assure additional capacity for future needs, Dravo installed a 1,500-gpm (top capacity 2,200-gpm) Walker process clariflow unit, together with the necessary pumps, chemical feeders, clear water storage reservoir, and the required building and foundations.

Creek water enters the new treating plant pump chamber through screens which stop floating debris. Three DeLaval centrifugal pumps each 750 gpm at 40 ft total dynamic head can be operated as needed to deliver the water into the Clariflow unit. Through chemical feeders, alum and lime are introduced into the

Figure 2 — The complete water treating plant stands on the bank of Chartiers Creek opposite the mill buildings. The 1500-gpm, Clariflow unit responds quickly to changes in chemical feed and water turbidity without causing unbalanced flow currents that produce troublesome "thunder heads."



pump discharge line. Alum serves as the coagulating agent and lime is used to raise the pH and reduce the iron content. Lime feed is adjusted to maintain a pH high enough to reduce the iron content without causing an appreciable coating inside the distribution piping. Biological growths and bacteria are controlled by chlorine feed.

Complete clarification takes place within four zones in the circular Clariflow unit. Pumped influent enters the inner or central chamber where by means of a motor driven mixer complete blending of the water, chemicals, and a small percentage of recirculated sludge is assured. From here the water flows into and through the flocculating, stilling and settling zones. Effluent overflows through V-notch weirs into the collecting trough and out into a balancing tank.

Accumulated sludge settles to the bottom of the Clariflow unit where motor driven scrapers aid in collecting it into a slurry hopper. It is then removed on an adjustable time cycle through an automatic Viggers valve. Operation of the Clariflow does not depend on a sludge blanket, thus it is able to start, stop and handle heavy surges without affecting the turbidity removal. The only use for sludge is the small amount pumped, on an adjustable time cycle, into the mixing and reaction chamber to act as seed for good floc formation. Another advantage of this type unit is that immediate response can be had from adjustments of chemical and water feed. Resistance heating cables strung at the water surface along the outer periphery of the settling zone prevent ice formation in the winter.

Three DeLaval centrifugal pumps, each 740-gpm at 90 ft total dynamic head, take effluent water from the balancing tank and deliver it into a 700,000 gal steel storage reservoir. The balancing tank takes care of unequal capacities of the raw and filtered water pumps caused by a change in head on the latter. Their pumping capacity falls off slightly as the level of water in the storage reservoir rises.

Accurate records of flow are kept through the use of two integrating and recording flowmeters, one on the influent line to the clarifier and the other on the mill supply line from the storage reservoir.

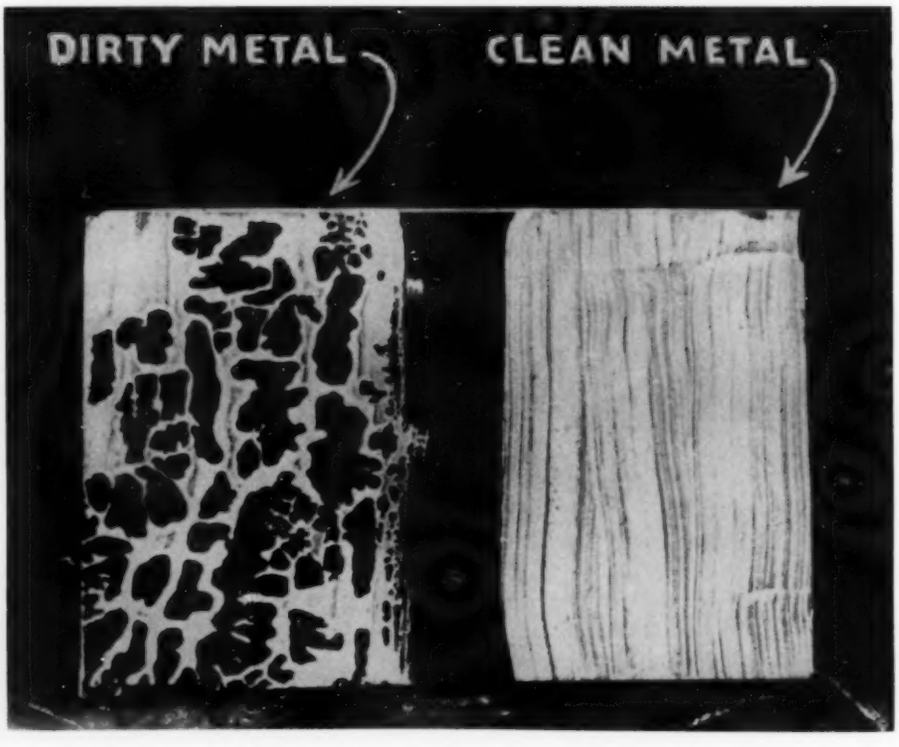
FLUX INDICATES IF SURFACE IS READY FOR BRAZING

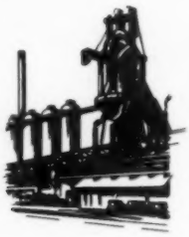
▲ GIVEN a well-cleaned, fluxed surface to work on, silver brazing alloys will wet easily to produce strong, leak-tight joints. Flux helps the molten alloy wet metals by reducing surface tension and by removing and inhibiting oxidation. But unless the flux itself wets the metal initially, there is little chance that the brazing alloy can do so. (This does not apply to the special alloys developed to silver-braze copper without flux.)

Flux is compounded to remove a certain amount of oil and oxide, such as are commonly encountered on mill supplied materials. However, excessive accumulations of dirt, grease, oil and oxides can retard wetting by both the flux and alloy. Consequently one can often tell if the brazing alloy is likely to wet by examining the way the flux adheres to a surface. To illustrate this point, technicians at the engineering laboratory of Handy & Harman, manufacturer of silver brazing alloys and fluxes, took a thoroughly oily steel plate which has been lying around the shop. They cleaned and degreased one half of the plate; the other half they left intact. They then applied standard Handy flux to each half. The results are shown in Figure 1. Note the even coating of flux on the cleaned half, and the flux-less islands on the oily half. If brazing were attempted on a piece in the latter condition, the alloy would wet so sparsely that a mechanically weak and probably leaky joint could be expected. If the flux wets poorly, the wisest and most economical thing to do is to clean and degrease the pieces before attempting to braze them.

The most common cleaning techniques are: remove any oxide on the joint surfaces by pickling or by touching to an abrasive belt or wheel. Follow by degreasing in a bath of carbon tetrachloride, trichloroethylene or similar solvent. When handling cleaned parts, do not touch the joint faces; a greasy finger print is as much of an offender as a patch of oil or oxide.

Figure 1 — Indicative of improper cleaning are the numerous islands at left where the flux did not wet the metal. If brazing were attempted on this dirty section, the brazing alloy would cover only the fluxed areas, leaving voids elsewhere.





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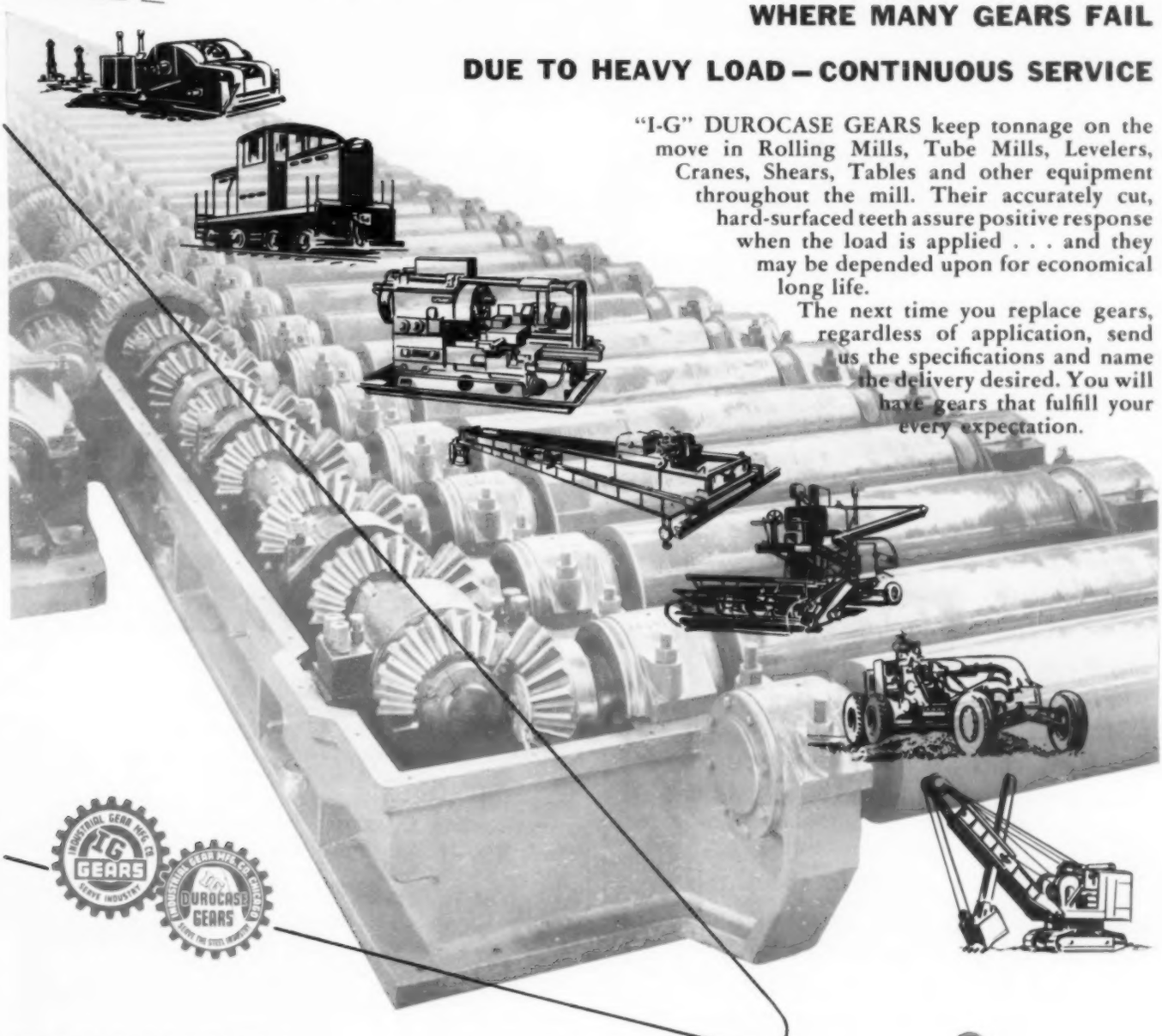

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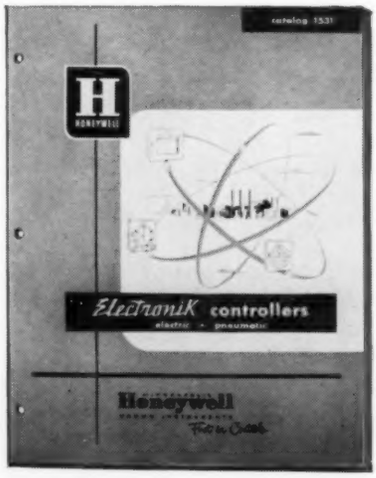

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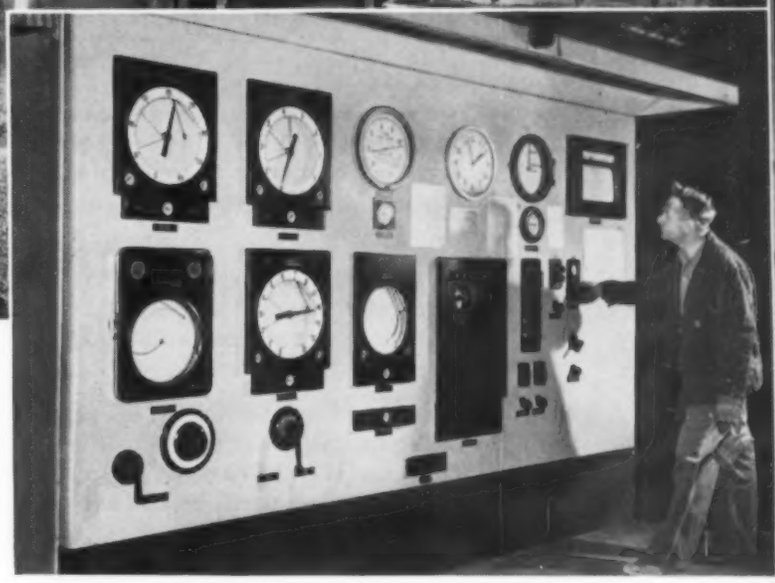


Big production at economical cost comes from this open hearth furnace at Ford Motor Company's Rouge Plant. Combustion and reversal are controlled by Brown instruments in this system which was engineered by Fennell Engineering Co., Inc.

with flexible *ElectroniK* control

AS PART of a thorough modernization program of steel producing facilities, Ford Motor Company has equipped the open hearth furnaces at the Rouge plant with up-to-date Brown instrumentation. By controlling vital variables with exceptional accuracy and dependability, this integrated system proves valuable in gaining top production at economical Btu rate per ton.

High combustion efficiency results from accurate proportioning of fuel, steam and air fed to the burners. Sensitive *ElectroniK* flow meters measure the flow of oil, coke oven gas and steam. Through interlocked control, they regulate flow of combustion air in proportion to total fuel, and steam flow in proportion to oil. A total Btu control system, using a *Tel-O-Set* indicator and controller, regulates fuel input to use all available gas . . . to maintain maximum economy.

Efficient reversals. *Radiamatic* elements, with an *ElectroniK* controller, measure checker temperatures. This instrument works with a Bloom pneumatic reversal unit. The overall speed and sensitivity of the system provides fast reversals and uniform checker temperatures.

Simplified maintenance. Manual by-pass panels on all controllers permit servicing or removal of the instruments without interrupting manual operation of the furnace.

Available from Honeywell is a complete line of instrumentation for controlling critical temperatures, flows and pressures in open hearth and other metallurgical furnaces. An experienced application engineering staff combines these components into integrated systems, custom-made for the individual furnace. For a discussion of your particular requirements, call your local Honeywell sales engineer . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

● **REFERENCE DATA:** Write for Catalog 1531, "*ElectroniK* Controllers," and for Data Sheets on specific furnace control applications.

H HONEYWELL

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

"WE CUT MOTOR REPAIRS FOR ONE OF OUR CUSTOMERS FROM 18 MOTORS PER YEAR TO 2 BY INSTALLING FUSETRON FUSES"

"The owner of a large poultry farm is one of our customers. In his operation a great number of motors are used in many different ways — pumps, feed grinders, heating systems, ventilators, etc.

"But these motors were giving him so much trouble that we were rewinding from 12 to 24 burned out motors a year for him.

"To correct the trouble, we suggested protecting the motors with Fusetron dual-element fuses. He told us to go ahead and try them. So, after checking the circuits and motors, Fusetron fuses were installed in proper sizes.

"Fusetron dual-element fuses proved themselves from the beginning. For the entire year following their application, only 2 motors were repaired and this trouble was caused by over lubrication.

"The motors we rewind are guaranteed for a year so we want to be sure they are properly protected. That's why we recommend to all our customers that they use Fusetron dual-element fuses."

Lawson E. Cobb
President
NEW ENGLAND ELECTRIC
MOTOR EXCHANGE INC.
GARDNER, MASS.

ROBERT E. HENRIKSON
Shop Foreman

FUSETRON is a trademark of Bussmann Mfg. Co.

Harlan F. Cobb
Vice President

FUSETRON dual-element FUSES do more than cut your motor repair costs

Fusetron fuses save you recalibration and maintenance costs

Fusetron fuses are *calibrated at the factory by engineers.* Once properly installed, they require no periodic inspection or down-time necessary on mechanically operated devices.

Fusetron fuses eliminate down-periods caused by needless blows

Fusetron fuses can increase production and reduce annoying interruptions of regular maintenance because — they wipe out needless blows caused by harmless overloads or excessive heating.

Fusetron fuses increase life of equipment

If there is an electrical fault, Fusetron fuses open and warn of danger and help hold fault to its source.

Panels and switches are protected against damage due to poor contact heating.

100,000 amp., interrupting rating gives you maximum safety

Fusetron fuses can safely interrupt the most severe available short circuit current — and are adequately safe to meet future circuit growth.

Fusetron fuses save on installation costs

They protect against waste of space and money by permitting use of proper size panels and switches, instead of oversize.

Lawson E. Cobb
President

Here's why Fusetron fuses give all-purpose protection

A fuse link combined with a thermal cutout — the result, a fuse with tremendous time-lag and much less electrical resistance and an interrupting rating in excess of 100,000 amps.

They have the same degree of Underwriters' Laboratories approval for both motor-running and circuit protection as the most expensive devices made.

Made to same dimensions as ordinary fuses. FUSETRON Fuses fit all standard fuse holders.

Obtainable in all sizes from 1/10 to 600 ampere, both 250 and 600 volt types. Also in plug types for 125 volt circuits.

Their cost is surprisingly low.

Write for bulletin FIS.

For loads above 600 and up to 5,000 amps., Use BUSS Hi-Cap Fuses . . .

They have unlimited interrupting capacity to handle any fault current regardless of system growth.

They can be coordinated with Fusetron fuses on feeder and branch circuits to limit fault outages to circuit of origin.

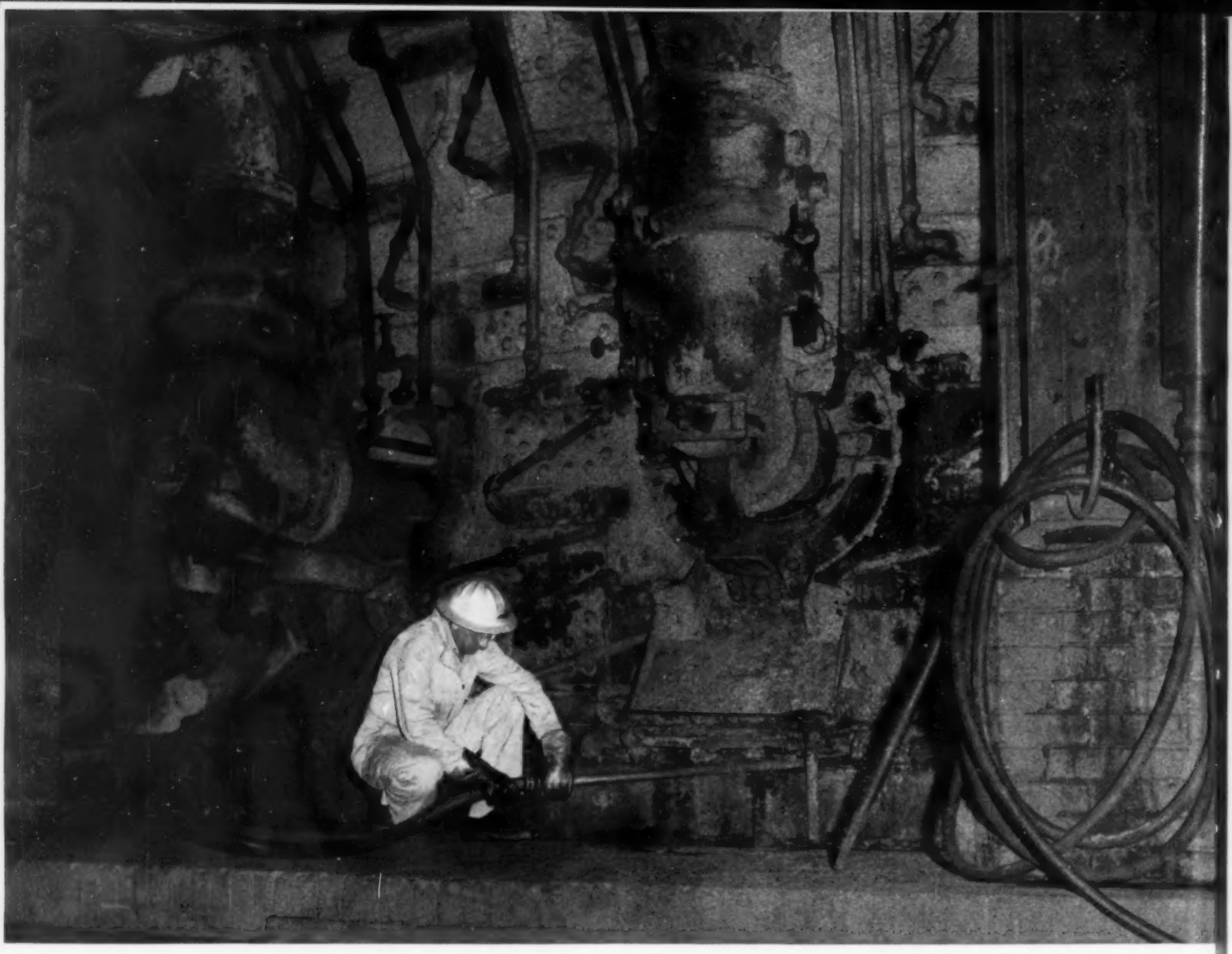
Write for bulletin HCS.

BUSSMANN MFG. CO. Div. of McGraw Electric Co.
University at Jefferson, St. Louis 7, Mo.

Play Safe! **install FUSETRON dual-element Fuses and BUSS Hi-Cap Fuses throughout entire Electrical System!**

FUSETRON
TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS

755



WATER FLOW INCREASED 380%

DOWELL chemically cleaned blast furnace cooling system with furnace on blast, lowering discharge temperature of cooling water 44°F.

A heavy deposit of iron oxide and sludge restricted water flow in the cooling system of a blast furnace. In many places the piping was two-thirds filled with scale, causing hearth cooling blocks to overheat and burn out.

With the furnace on blast, Dowell engineers used solvents to remove the deposits. After chemical cleaning by Dowell, the operator's tests showed water flow had increased over 380% and the discharge temperature had dropped 44 degrees.

Among the many kinds of equipment regularly cleaned by Dowell are pipe lines, boilers, condensers, gas mains, open hearth checkers, stoves and other gas cycle equipment.

Dowell brings job-tailored solvents and the necessary cleaning equipment into your plant. Solvents are applied according to the technique best suited to the job—filling, spraying, jetting, cascading or vaporizing. Dismantling and downtime are eliminated or held to a minimum.

Don't gamble production against scale and sludge. Call your nearest Dowell office for information and estimates on cleaning your equipment. Or write to Dowell Incorporated, Tulsa 1, Oklahoma, Dept. G-29.

chemical cleaning service for industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Date-line Diary...

June 2

▲ The United Auto Workers of the Ford Motor Co. extended their contract until next week to examine a new offer from company officials.

▲ Manufacturers sales in April dropped $1,200,000,000 from March to $26,400,000,000 but was up $2,400,000,000 from April 1954, according to the Commerce Dept.

▲ The F. W. Richmond group of New York has acquired the National Valve and Manufacturing Co. of Pittsburgh, a fabricator and erector of spring piping systems for utilities and chemical plants.

June 3

▲ Ford Motor Co. proposed to set up a $55,000,000 security fund for compensation to laid-off employees. This still did not meet the demands of the union.

▲ Rail freight loadings increased last week to 790,176 cars, up 2 per cent from the previous week and 14.6 per cent above the like period in 1954.

June 4

▲ Bethlehem Steel's offering of $191,700,000 of new 25-year, 3¼ per cent convertible debentures was a success with 96 per cent purchased by stockholders.

▲ Westinghouse Electric Corp. made known a net income after taxes of $12,782,000 or 75¢ per common share on net sales of $367,705,000 for the first three months of 1955 in comparison with a net income of $26,286,000 or $1.61 per common share on net sales of $406,537,000 for the like period in 1954.

June 6

▲ The AISI reports that the operating rate of the steel industry for the week of June 6 is scheduled at 96.7 per cent of capacity. This is equivalent to 2,334,000 tons compared with 2,312,000 tons one week ago, and 1,746,000 tons one year ago. Index of production for the week is 145.3.

▲ U. S. Steel Corp. began wage negotiations this week with the CIO Steelworkers. Due to the outstanding increase in steel buying and orders, the union expects to win a settlement beyond the 9 to 12¢ increase obtained last year.

▲ Personal income receipts in April amounted to a yearly rate of $295,600,000,000 which is $1,000,000,000 above March and $11,200,000,000 above April one year ago.

June 7

▲ Contract settlements were reached by the Ford Motor Co. and the CIO United Auto Workers by granting benefits equal to an increase of 20¢ per hr. A modified guaranteed annual wage was part of the package.

▲ According to the Association of American Railroads, Class I railroads had a net income in April amounting to $67,000,000 an increase over the $40,000,000 net income in April of 1954.

June 8

▲ The F. W. Dodge Corp. reports contract awards for the 37 states east of the Rockies totaled $2,185,065,000 in May bringing 1955's five-month total to $9,727,562,000 or 29 per cent above the previous year's figure for this period.

▲ Ford Motor Co.'s nine plants across the country were closed resulting from walkouts of dissatisfied workers with the contract agreements reached by the CIO United Auto Workers and company officials.

▲ Employment in May reached 62,703,000, an increase of 1,018,000 over April and 1,500,000 above May one year ago. This is a new high for the month.

June 9

▲ The Senate has approved the proposal to raise the minimum wage from the present 75¢ rate to $1.00 per hr which is 10¢ more than President Eisenhower has asked.

▲ CIO United Steelworkers' president, David J. McDonald, said the union will bargain on wages only this year despite the CIO United Auto Workers' gaining a modified form of guaranteed annual wage from Ford Motor.

June 10

▲ Allegheny Ludlum broadened their pension program so that union members can now arrange for pensions at lower monthly rates, which would continue after death to dependents, a step taken by Bethlehem Steel Co. two months ago.

▲ The Aluminum Association reported primary production of aluminum in April totaled 252,788,467 lb in comparison with 260,543,479 lb in March and 240,867,314 lb in April 1954.

June 13

▲ The AISI reports that the operating rate of the steel industry for the week of June 13 is scheduled at 96.5 per cent of capacity. This is equivalent to 2,330,000 tons compared with 2,286,000 tons one week ago and 1,725,000 tons one year ago. Index of production for the week is 145.0.

▲ The CIO Steelworkers stated they will demand a pay increase above the 7½¢ per hr which is their estimate of the increase which Ford Motor Co. granted the United Auto Workers.

▲ According to the president of the Edison Electric Institute, Harold Quinton, electricity generating capacity in the U. S. will reach 138,000,000 kw by 1959.

June 14

▲ CIO Auto Workers signed a new three-year contract with General Motors yesterday. The contract was quite similar to that signed with Ford.

▲ Straits tin advanced to 93⅞¢ per lb in New York in comparison with 91⅞¢ one week ago.

▲ The Mineral Industry Surveys report of the United States Dept. of the Interior, Bureau of Mines reported consumption of ferrous scrap during April totaled 6,238,000 gross tons, a slight drop from the 6,313,717 gross tons in March. Of this about 3,500,000 tons were home scrap.

June 15

▲ Arthur B. Homer, president of Bethlehem Steel Co. predicted that steel demand would reach 200,000,000 tons annually, or more than 50 per cent above the present rate.

June 16

▲ The Aluminum Association reported primary aluminum production in May 1955 totaled 262,256,336 lb in comparison with 252,788,467 lb in April and 250,276,637 in May one year ago.

▲ Electricity output totaled 10,041,000,000 kwhr, the second highest in history, and 16 per cent above this period in 1954.

▲ Ford Motor Co. announced plans for alterations to its two Cleveland plants and foundry to give them greater V-8 engine capacity.

June 17

▲ Zinc advanced ½¢ to 12½¢ a lb in East St. Louis.

▲ Soft coal production for last week was the highest since October 1953 with a total of 9,300,000 tons, up 1,800,000 tons from the corresponding week in 1954, and the highest level in 19 months.

June 20

▲ The ARCI announced deliveries of new domestic freight cars in May totaled 4083 in comparison with 2750 in April and 3173 in May 1954. Orders for 3041 were placed in May leaving a backlog of cars on order as of June 1 totaling 15,615.

▲ According to the AISI, production by blast furnaces set a record in May with output of pig iron and ferro alloys totaling 6,804,935 net tons with furnaces operating at an average of 95.4 per cent of capacity. This output compares with 6,677,361 net tons in the previous high month of March, 1953.

▲ The AISI reports that operating rate of the steel industry for the week of June 20 is scheduled at 97.4 per cent of capacity. This is equivalent to 2,350,000 tons compared with 2,316,000 tons one week ago and 1,720,000 tons one year ago. Index of production for the week is 146.3.

June 21

▲ Pennsylvania Railroad's net earnings were $5,100,000 in May, highest for this month since 1945, in comparison with around $3,000,000 in May 1954. This brought the five month total to $16,300,000 or $1.24 a share in comparison with a deficit of $681,124 in the like 1954 period.

June 22

▲ The Labor and Commerce Depts. estimated construction spending this year to amount to $41,800,000,000 which is $4,200,000,000 above the previous high in 1954.

▲ Incoming orders for machine tool makers in May climbed to $72,150,000 an increase of $19,500,000 over April and $31,000,000 above May 1954. Bookings for the first five months rose to $310,000,000 which is up $68,000,000 from the like period in 1954.

June 23

▲ U. S. Steel Corp. offered to increase hourly rates of the CIO Steelworkers in amounts ranging from 6½¢ to 22¢ per hr for the lowest job class to the highest.

▲ Large expansion programs by both General Motors and Ford being started will bring General Motors post-war spending to $4,000,000,000 and Ford's to $2,300,000,000 by early 1957.

June 24

▲ The Air Force placed orders totaling $11,000,000 for machine tools for stockpiling and will buy an additional $50,000,000 by September and expects to place a total of around $84,000,000 by the end of 1955.

▲ The public debt limitation is expected to remain at $281,000,000,000 until June 30, 1956. This includes the $6,000,000,000 increase which was authorized last year.

June 25

▲ The Electro Metallurgical Co., Div. of Union Carbide and Carbon Corp. announced reductions of $5.10 and $1.60 in the price for ferrocolumbium and ferrotantalum-columbium, effective July 1. New base prices are $6.90 and $4.65 respectively.

June 27

▲ The AISI reports that operating rate of the steel industry for the week of June 27 is scheduled at 96.1 per cent of capacity. This is equivalent to 2,320,000 tons compared with 2,292,000 tons one week ago and 1,568,000 tons one year ago. Index of production for the week is 144.4.

▲ According to the AISC, May bookings of fabricated structural steel amounted to 304,498 tons compared with 270,226 in April and 199,383 tons in May 1954. Shipments in May totaled 223,184 tons leaving a backlog of work ahead as of May 31 of 1,592,384 tons.

June 28

▲ CIO Steelworkers said they would use a selective strike strategy in their efforts to win a wage above the 10¢ per hr which they have been offered.

▲ Bethlehem Steel Co. reports that its annual productive capacity for finished products has increased 55 per cent during the last 10 years.

June 29

▲ Various steel producers started shutting down their furnaces in preparation for the threatened strike.

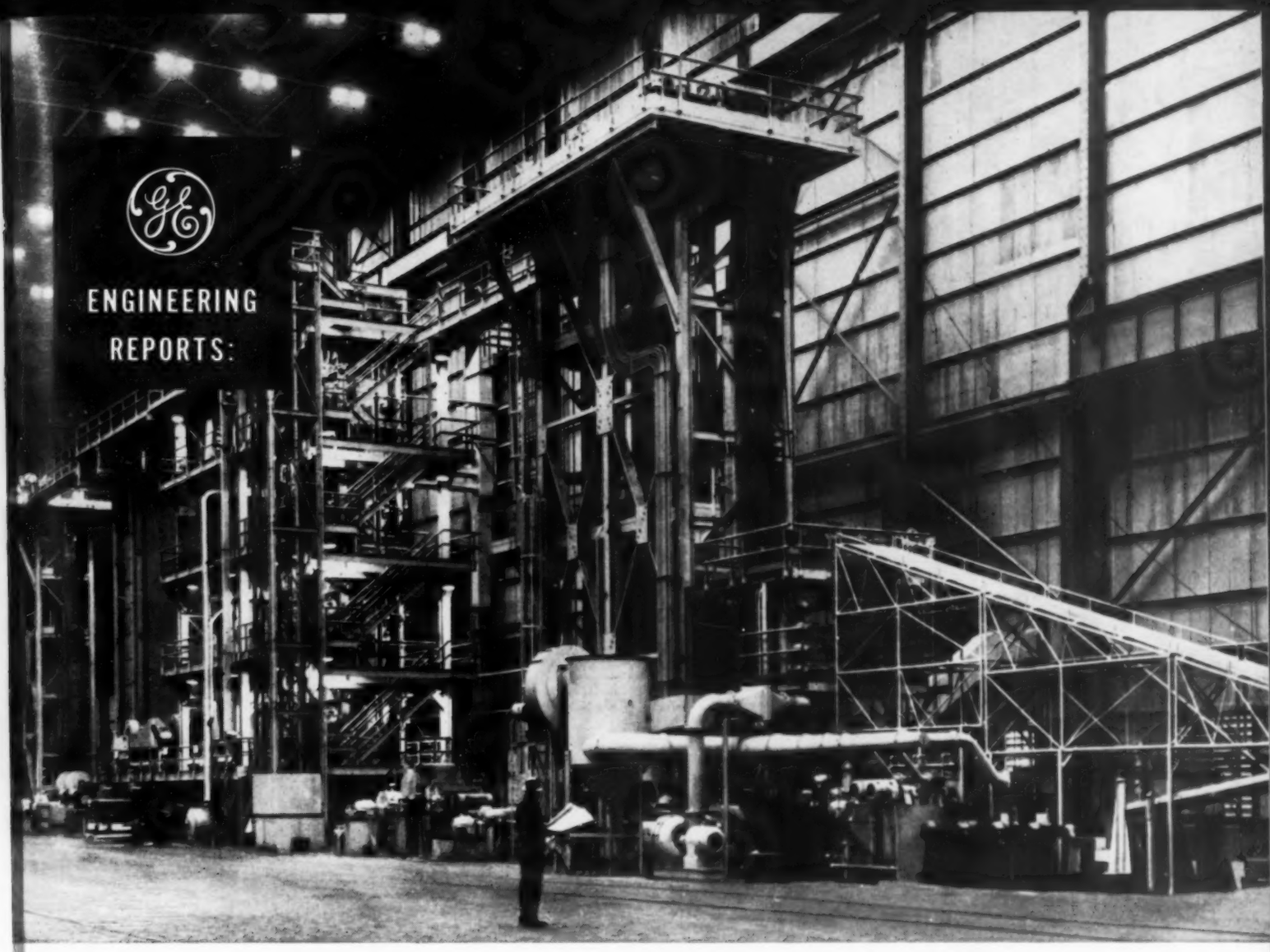
June 30

▲ Electric power output reached a record 10,226,000,000 kwhr for the week ending June 25 which was 13.9 per cent over the same week in 1954 and 179,000,000 kwhr above the previous high set in the week ending February 5, 1955.

▲ According to the AISI, employment in the iron and steel industry rose to 654,000 in May in comparison with 643,200 in April. Working hours averaged 39.7 hr per week during May in comparison with 39.9 hr in March, at an average hourly payroll cost of $2.404. Total payroll in May was $294,073,000 and was $282,025,000 in April.

▲ The Commerce Dept. reported manufacturers booked new orders totaling $26,700,000,000 in May in comparison with $21,100,000,000 for May of 1954.

▲ The Association of Americans Railroads reported rail freight loadings for the first half of 1955 were 6.22 per cent above the first half of 1954.



G-E VERTICAL ANNEALING FURNACE at Fairless Works is one of largest in world. Strip is annealed at rate of 1000 fpm

Drive-engineered by General Electric . . .

New Fairless line anneals 30 tons/hr

Running at speeds up to 1000 feet per minute, U. S. Steel's new cleaning and annealing line at their Fairless Works, Fairless Hills, Pa., produces clean, bright, uniformly annealed strip at the rate of 30 tons per hour. This continuous processing line is a typical example of the drive-engineering and equipment applied to many of the new Fairless lines by General Electric.

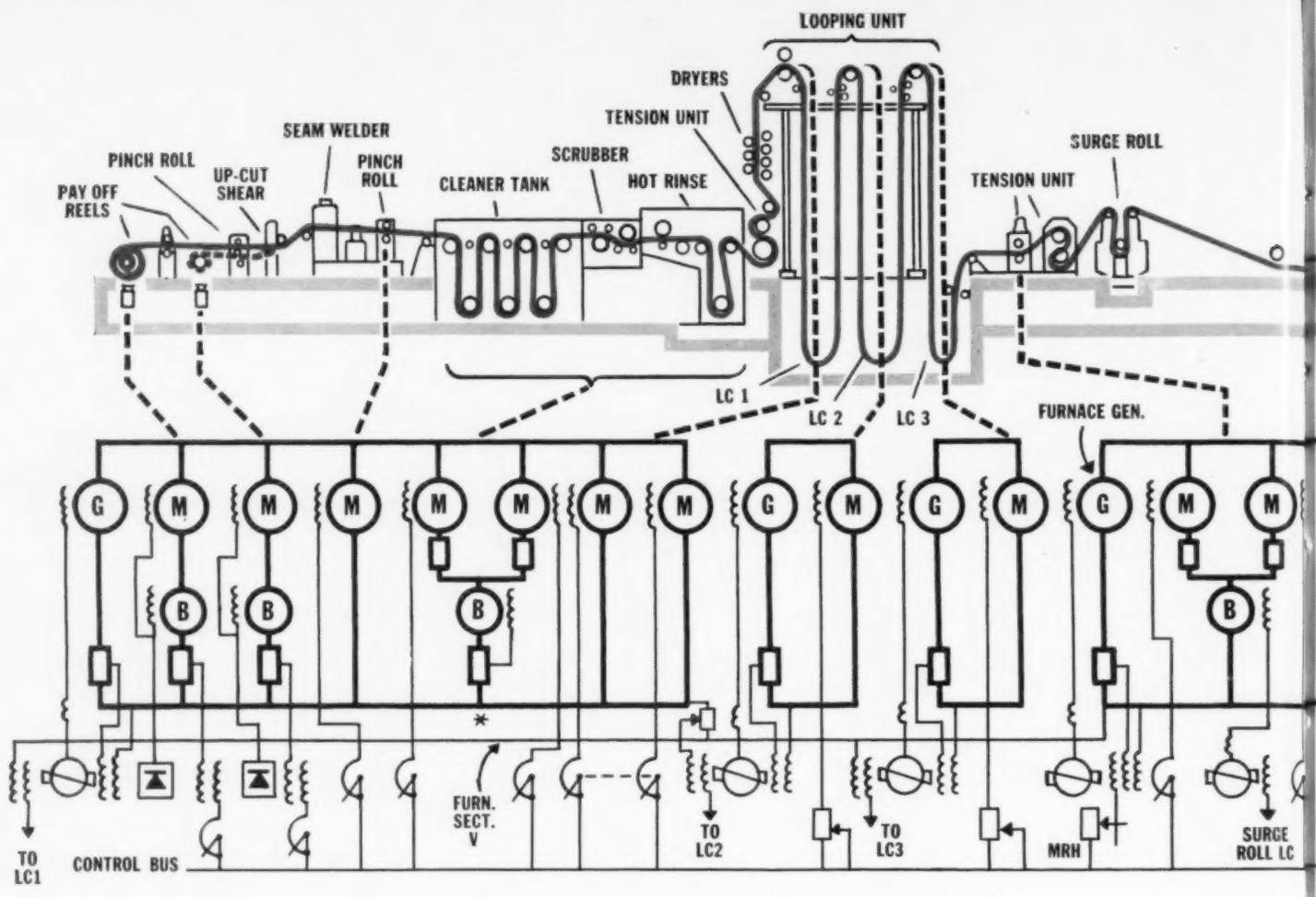
It is also another example of the teamwork performed between the customer, his machinery builder, and General Electric. Engineers from U. S. Steel, United Engineering and Foundry Co., and General Electric worked together to design this annealing line which is one of the fastest in operation today.

The entire line operates under automatic control, and handles strip from 18 to 37 inches wide. The use of a G-E annealing furnace—one of the world's largest—and vertical loops permits the accommodation of 3000 feet of strip between the two ends in a floor length of only 385 feet.

The same G-E engineering skill which was utilized on this high-speed annealing line is available to you. If you are planning to build, expand, or modernize your facilities, contact your Apparatus Sales Representative at the nearest G-E Apparatus Sales Office. General Electric, Schenectady, N. Y. 659-107

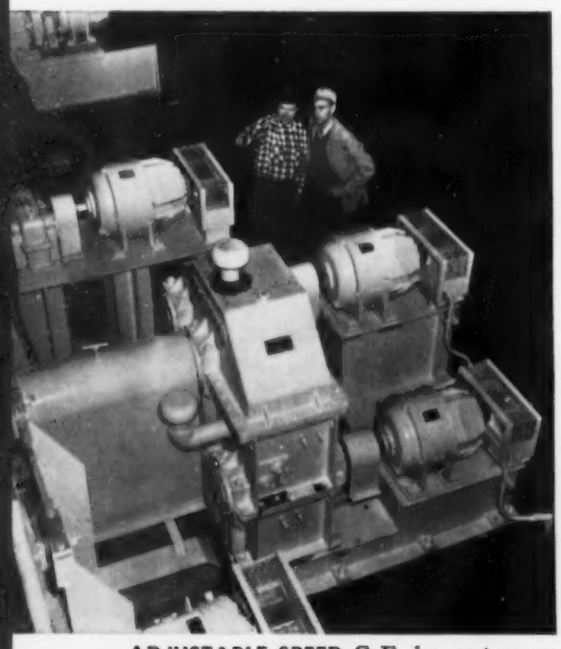
ADVANTAGES OVER BATCH METHODS

GENERAL ELECTRIC



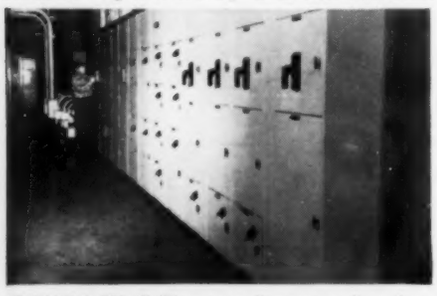
Powered by a General Electric drive system...

New Fairless continuous annealing line



ADJUSTABLE SPEED G-E d-c motors on tension bridle help maintain constant strip tension in furnace.

AUTOMATIC CONTROL of gas fired and electrical heating and cooling zones of furnace is provided by G-E control unit.



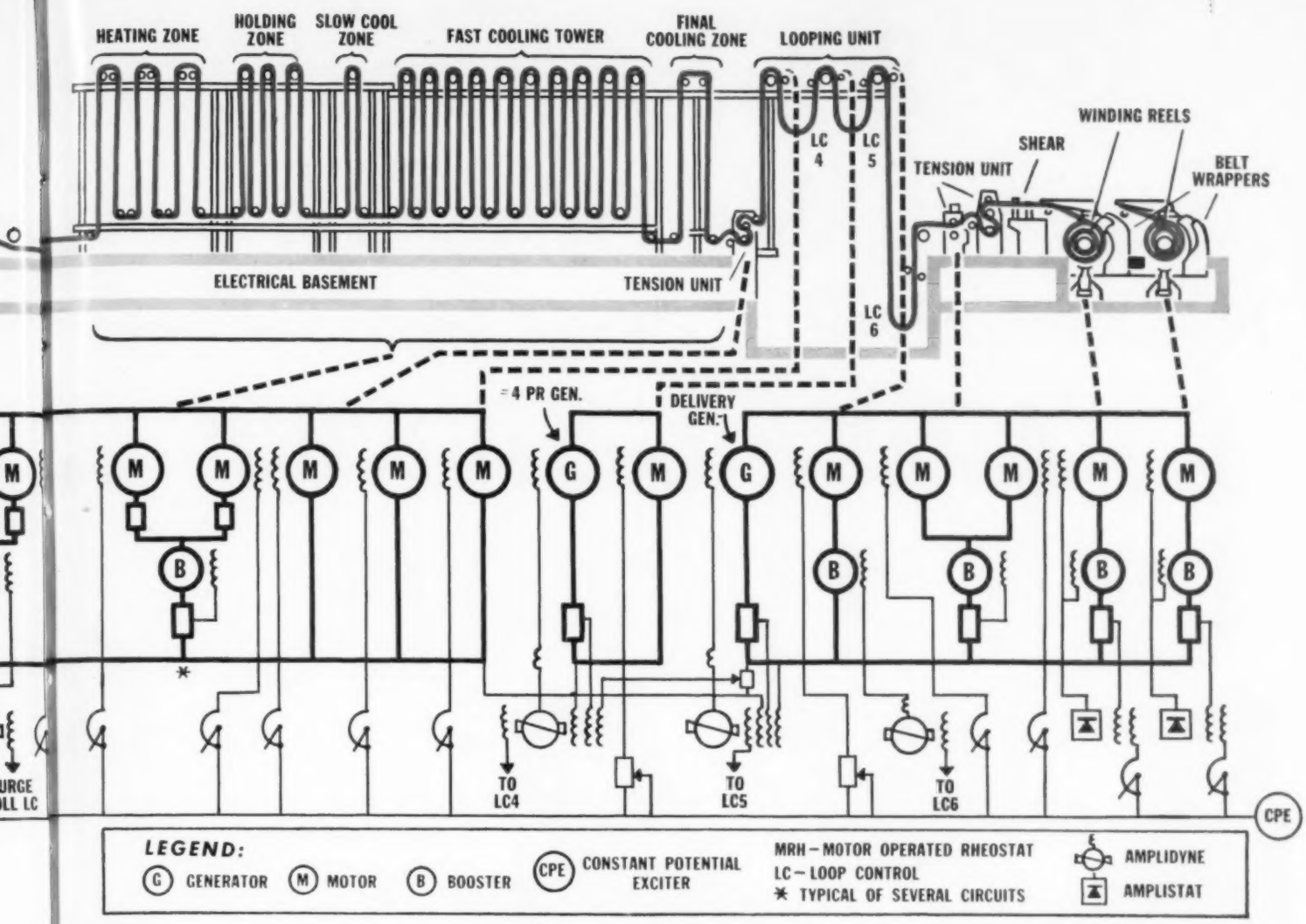
COMPACT G-E control center for fans, pumps, and auxiliary m-g sets is located in electrical basement.

HOW THIS DRIVE WORKS

A motor-operated rheostat sets line speed by controlling the furnace-section generator voltage. Voltages of the entry and delivery section drives, and the tower pinch rolls, are regulated to keep the entry storage loops full and the delivery storage loops empty during normal running. The furnace-section voltage is used as a reference for an approximate speed match, with the photoelectric loop controls (LC) acting as over-riding vernier regulators to maintain accurate loop position.

To start a new coil, the entry section is decelerated to a stop under current limit, while the "half-speed pinch roll" (No. 1PR) empties the loops evenly. This permits the strip to continue through the furnace at a constant speed during the time required to weld toegther the ends of the new and old coils. The entry section is then accelerated, again under current limit, to an overspeed condition until the storage loops are refilled. Full coils of annealed strip are removed from the delivery end of the line in a corresponding manner.

Another example of G-E drive engineering at work!



has 5 advantages over batch methods

1 Increases output **2** Improves product **3** Saves time

4 Saves manpower **5** Saves space

Fairless' new continuous cleaning and annealing line at Fairless Hills, Pa., is an excellent example of the progress that has been made in the continuous processing field. Powered by a General Electric drive system, the new line, which can process 30 tons of steel per hour at speeds up to 1000 fpm, has these five advantages over batch methods.

1. **INCREASES OUTPUT.** Continuous high-speed operation of line 24 hours a day speeds output.
2. **IMPROVES PRODUCT.** Precise temperature control of furnace gives strip greater uniformity, with improved flatness, and cleaner surface.
3. **SAVES TIME.** High speed of line reduces coil annealing time from days to minutes. There is no need to transport coils from cold mill to cleaning unit to furnaces.
4. **SAVES MANPOWER.** Amplidyne control of tension, loop positioning, and overspeeding provides high degree of automatic operation.
5. **SAVES SPACE.** By combining cleaning and annealing, floor space is reduced by more than a third.

You also profit when you specify General Electric to help design your continuous processing line electrical systems. Experienced G-E steel mill processing line engineers are available to work with you and machinery manufacturers to construct modern, high-speed lines. For further information, contact your G-E Apparatus Representative, or write for bulletin GEA-6017, "Engineered Electrical Systems for Continuous Metal Processing." General Electric Co., Schenectady, N. Y.

659-107

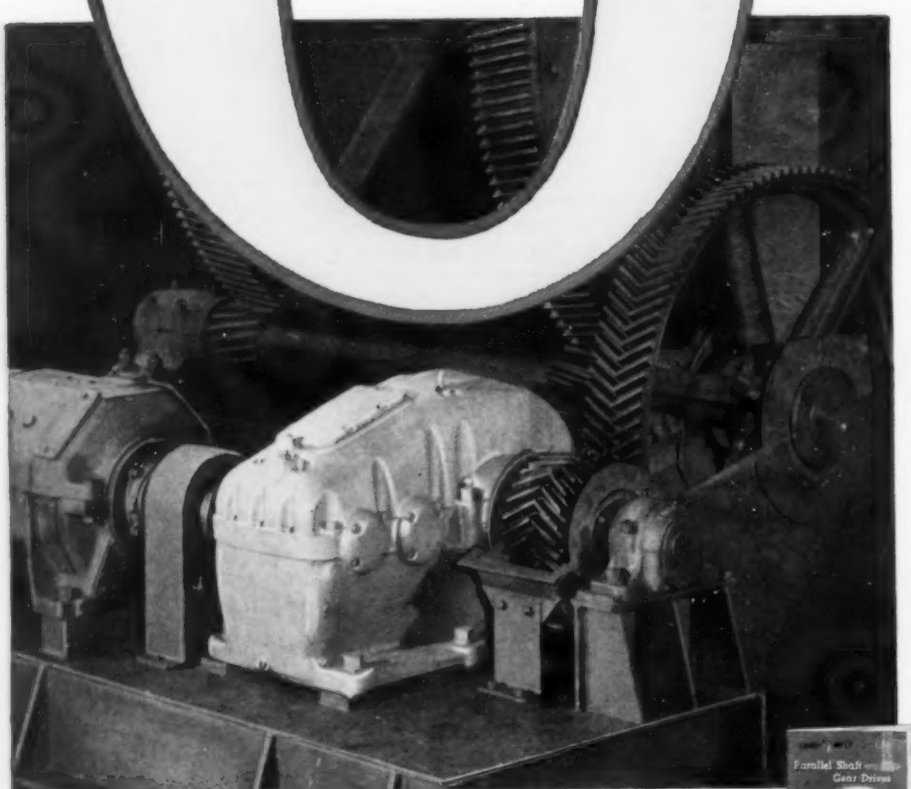
Engineered Electrical Systems for Steel Mills

GENERAL ELECTRIC

6 reasons why

Link-Belt Parallel Shaft Gear Drives

ASSURE CONTINUOUS PRODUCTION



Ten-ton coils of hot strip steel are transferred by this up-ender in a modern mill. Link-Belt parallel shaft gear drive fitted with outboard bearing on output shaft withstands the exceptionally tough duty.

LINK-BELT'S compact, self-contained parallel shaft gear drives are designed to avoid common problems encountered in transmitting heavy shock loads. Here's how:

1. FOR DEPENDABLE OPERATION gears are precision-machined, shafts rigidly supported.
2. TO WITHSTAND HEAVY SHOCK and overhung loads, ball and roller bearings are used throughout.
3. TO PREVENT ENTRANCE OF DIRT and moisture, effective grease-lubricated seals are used on all shafts.
4. FOR SUPPLYING OIL to each rotating part at all speeds, automatic splash lubrication is used.
5. TO PREVENT REVERSE ROTATION on conveyors, elevators and similar equipment, a built-in backstop can be provided.
6. FOR EASY INSPECTION OR MAINTENANCE, all parts can be removed without disturbing base, which can be grouted in concrete.

Book 2619 gives complete details. Get a copy from your Link-Belt office or authorized stock carrying distributor. Or write direct.

Get JOB-MATED drive combinations from the complete Link-Belt line

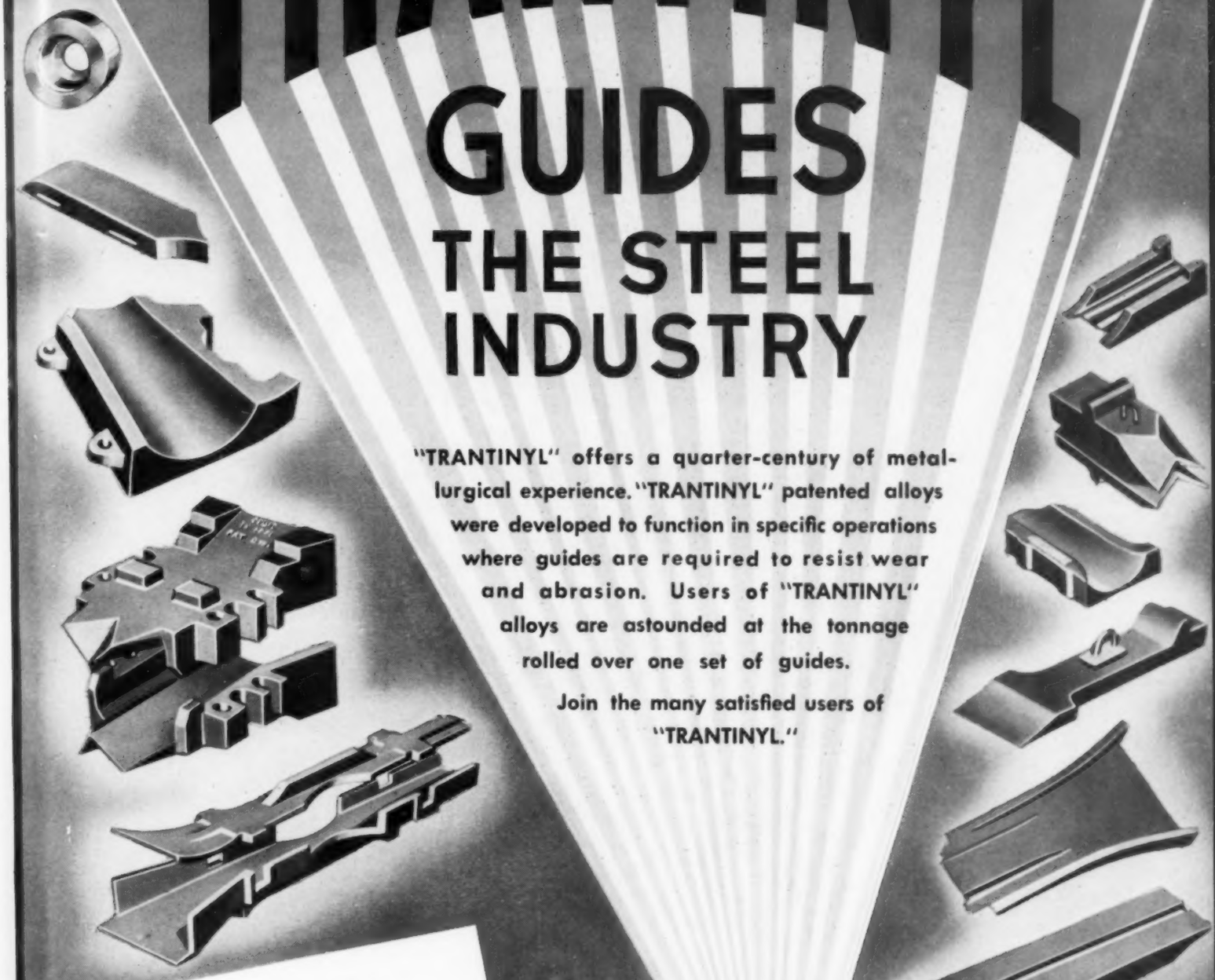
In addition to parallel shaft gear drives, Link-Belt builds in-line helical and worm gear drives, Gearmotors, Motogears, variable speed drives, fluid drives, chains, sprockets, couplings, bearings, etc. All are pre-engineered for easy installation and maximum efficiency.

LINK-BELT

ENCLOSED DRIVES

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,074

TRANTINYL GUIDES THE STEEL INDUSTRY



"TRANTINYL" offers a quarter-century of metallurgical experience. "TRANTINYL" patented alloys were developed to function in specific operations where guides are required to resist wear and abrasion. Users of "TRANTINYL" alloys are astounded at the tonnage rolled over one set of guides.

Join the many satisfied users of "TRANTINYL."

ROLLING MILLS:
bar, hoop, strip, shape mill guides; and rollers.

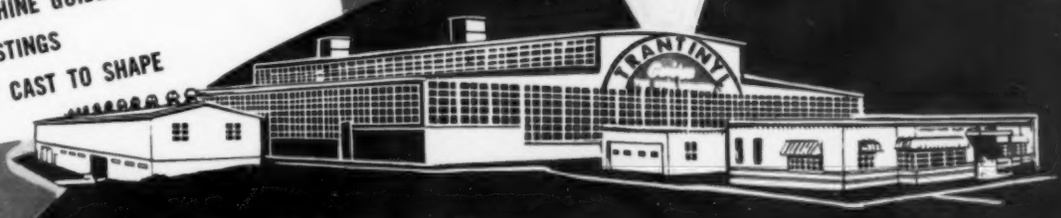
SEAMLESS TUBE MILLS:
guide shoes, rolling mill plugs and rolls, piercer points, etc.

ELECTRIC WELD TUBE MILL:
forming rolls, planishing rolls, tool holders, etc.

STRAIGHTENING MACHINE GUIDES

HEAT RESISTING CASTINGS

"TRANTINYL No. 1" CAST TO SHAPE



Youngstown Alloy Casting Corporation
Youngstown, Ohio

G-110

baby doing nicely thank you!

FORGED ROLLS

The Ohio Steel Formula for Blue Ribbon Rolls

HARDNESS
STRENGTH
UNIFORMITY
CONSISTENCY

Ohio Rolls

SHAPING METAL FOR ALL INDUSTRY

THE OHIO STEEL FOUNDRY CO.

LIMA, OHIO • Plants at Lima and Springfield, Ohio

Industry News...

U. S. STEEL TO INSTALL SHEET AND STRIP FACILITIES AT VANDERGRIFT AND GARY PLANTS

▲ United States Steel Corp. announced that it is proceeding with the installation of facilities to produce continuous cold rolled light and heavy gage stainless steel sheets and strip at its Vandergrift, Pa., plant, and increasing the capacity for these products at its Gary sheet and tin mill plant.

The new equipment to be installed at Vandergrift will include a Sendzimir rolling mill, annealing and pickling lines, shearing and slitting equipment and the necessary auxiliary facilities.

In addition to the new facilities, the program will include moving equipment now being used for finishing hand-mill stainless sheets at Wood Works in McKeesport, Pa., to the Vandergrift plant, where these sheets are now being rolled. This move is designed to concentrate rolling and finishing facilities for both cold rolled and hand-mill stainless steel sheets at one location in the Pittsburgh district.

When the entire program is completed, the Vandergrift plant will have a yearly capacity for producing over 10,000 tons of continuous cold rolled stainless sheets. Completion is expected in about 20 months.

The increase in capacity at Gary is principally accomplished through the installation of a wheelabrator. Also, additional annealing capacity will be secured through the installation of a 90-ft annealing furnace which will be one of the longest single furnaces in the world. Other equipment included in the modernization will be new uncoilers, feed levelers, recoilers, new scrubbers and shearing equipment, and traveling spot welders. This will result in a substantial increase in capacity.

AWARDS CONTRACT FOR BLOOMING MILL

▲ Henry Roemer, chairman of the board of Sharon Steel Corp., announces the awarding of a contract for a 44-in. blooming mill. The new mill, with a capacity of 100,000 tons of ingots per month, will be installed at Sharon Steel's Roemer Works, Farrell, Pa.

Complete with buildings, electrical equipment, soaking pits, and all necessary facilities—the cost will be approximately $13,500,000. Construction is to start immediately, with completion scheduled by July 1, 1956.

This is another important step in Sharon's program of modernization and improvement at the Roemer works. The company recently blew in its No. 3 blast furnace, which was completely relined and equipped with top blast pressure. In addition, a new 300-ton open hearth furnace was put into operation recently.

UNION AND U. S. STEEL SIGN WAGE AGREEMENT

▲ United States Steel Corp. and the United Steelworkers of America reached an agreement July 1 providing for an increase in standard hourly wage rates amounting to an average in excess of 15 cents per hour, or more than 7½ per cent.

The negotiations occurred under a re-opening provision of the two-year agreement negotiated a year ago and were limited to adjustments in standard hourly wage rates. The basic agreement between the parties expires June 30, 1956.

On July 2 the corporation announced an increase of about 5.8 per cent in its steel prices.

In announcing the new price schedules, which went into effect July 6, Clifford F. Hood, president of U. S. Steel, said that the increase was made necessary not only by the rise in employment costs under the new wage contract, but also by the steadily mounting costs of purchased goods and services, of state and local taxes, and of new construction.

"For the past 15 years, now," Mr. Hood declared, "U. S. Steel — like other American businesses—has had to contend with powerful inflationary forces which have seriously affected every phase of its operation.

"During this period, its hourly employment costs have risen 193 per cent. In addition, the cost of the goods and services it buys and the state and local taxes it pays, also increased very substantially. At the same time the index of construction costs mounted by more than 170 per cent. Yet the index of its steel prices has increased by only 109 per cent.

DIE-BLOCK FURNACE EMPLOYS RADIANT HEAT

This gas-fired die block heating furnace, in use at the Heppenstall Co.'s Pittsburgh, Pa., plant, was designed and built by Selas Corp. of America. The unit employs patterned radiant heat under completely automatic program control. The furnace, specially engineered for die-block heating, is designed to heat a 38,000 lb work load—equivalent to a single die block 16 in. thick x 36 in. high x 20 ft long—in only 3 to 4 hr cycles (based on thickness of work.)

HERE'S THE USG® BRUSH THAT DOES AN OUTSTANDING JOB ON ALL YOUR MILL MOTORS

When you replace the brushes on your mill motors, you can get the best results with U S G Grade 135 Brush with Statite®. For brushes that give superb results in other applications, see below. Write for your copy of the complete U S G Brush catalog today.

A typical U S G Grade 135 Mill Motor Brush with Statite*

U S G Grade 1658 Brush for tin line collector rolls

U S G Grade 223 Brush for DC crane motors with Statite*

U S G Grade AH897 Brush for Welding generators with Statite*

U S G Grade 550 for AC Crane Motor Rings

*Permanent shunt connection, needing no hammerclips; cannot be jarred loose or pulled out.

203

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

BEGIN WORK ON BAR MILL FOR NORTHEASTERN STEEL

▲ Birdsboro Steel Foundry & Machine Co., has started manufacture of a specialty merchant bar mill ordered by Northeastern Steel Corp. for its plant in Bridgeville, Conn.

The new mill, designed for the production of high-grade alloy and stainless steel bars, as well as the usual carbon grades, will be in operation early in 1956, according to E. A. Schwartz, president of Northeastern.

"Addition of the new bar mill, together with the new electric furnaces, will increase our overall capacity to 300,000 tons of ingots annually, and will diversify our product line," Schwartz said.

The company, incorporated in December, 1954, now produces hot rolled carbon and alloy strip steel. On completion of the full program, entailing an expenditure of more than $8,000,000 Northeastern will be producing hot rolled and cold finished bars in a complete range of carbon, alloy, and stainless grades.

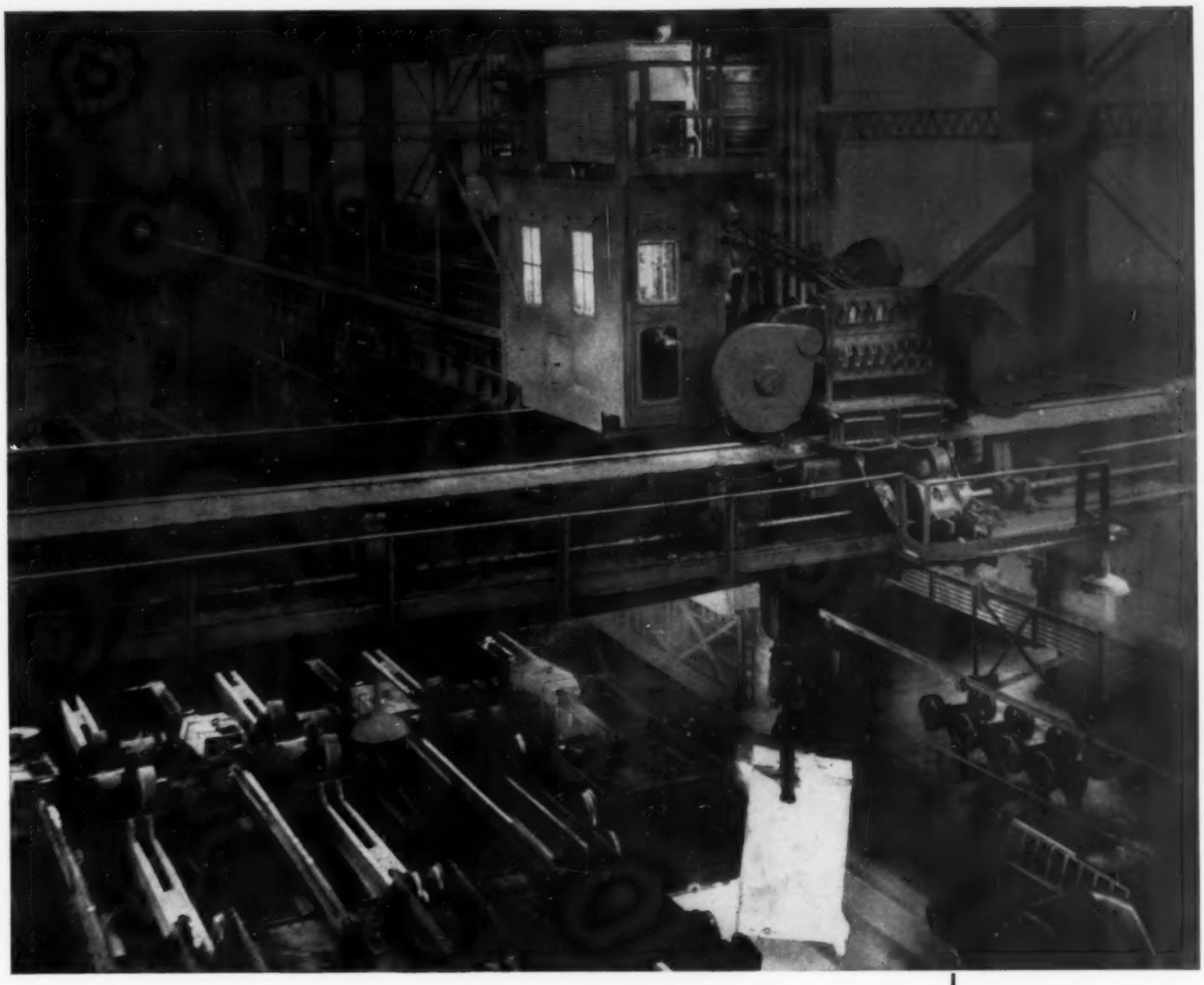
Work will be started shortly on a 700-ft addition to an existing 200-ft building to house the mill on Northeastern's 40-acre site on Bridgeport harbor.

PURCHASES VULCAN CRUCIBLE STEEL CO.

▲ The Vulcan Crucible Steel Co., Aliquippa, Pa., tool steel manufacturers, has been purchased by H. K. Porter Co., Inc.

Founded in 1901, Vulcan has annual sales of close to four million dollars. James O. Flower, the concern's president, will be vice president and general manager of the new division. Branch offices are located in Chicago, Detroit, and Boston, while sales representatives are in New York, Baltimore, Lansing (Mich.), Milwaukee, and St. Louis. The sales organization for Vulcan in the South will be that of Porter's Connors Steel Division, Birmingham, Ala., and warehouse stocks of Vulcan products will be established in Birmingham to serve the nearby eight-state area.

Vulcan's factory and offices are on an 18-acre site along the west bank of the Ohio River at Aliquippa.



Here's how to eliminate crane down-time due to summer heat

Is your steel mill constantly plagued with that annual problem of increased crane downtime caused by summer heat? With ambient temperatures up to 170° F over soaking pit, open hearth, heat treating and similar areas accentuated by high summer temperatures . . . plus dust, dirt and fumes . . . it's no wonder that crane operators need frequent relief—relief that results in *crane downtime* and *lost production!*

These problems are eliminated with Dravo Crane Cab Conditioners. The crane cab conditioner maintains a summertime temperature in the cab of 80 to 85° F . . . filters out dust, dirt and fumes . . . keeps crane operators alert and efficient . . . permits them to work long periods without relief. Dravo Crane Cab Conditioners will assure regular crane operations during those summer hot spells and help maintain production.

Get complete information *today* about how Dravo Crane Cab Conditioners can eliminate these problems and save you money! Mail the coupon.

DRAVO
CORPORATION
PITTSBURGH, PENNA.
Sales Representatives In Principal Cities

Dravo Corporation, Dept. B-1507
Fifth and Liberty Avenues, Pittsburgh 22, Penna.

DRAVO

- ☐ Please send Bulletin "Crane Cab Conditioners."
- ☐ Please send Bulletin "Cool Off the Hot Spots."
- ☐ Please have a representative call at no obligation to me.

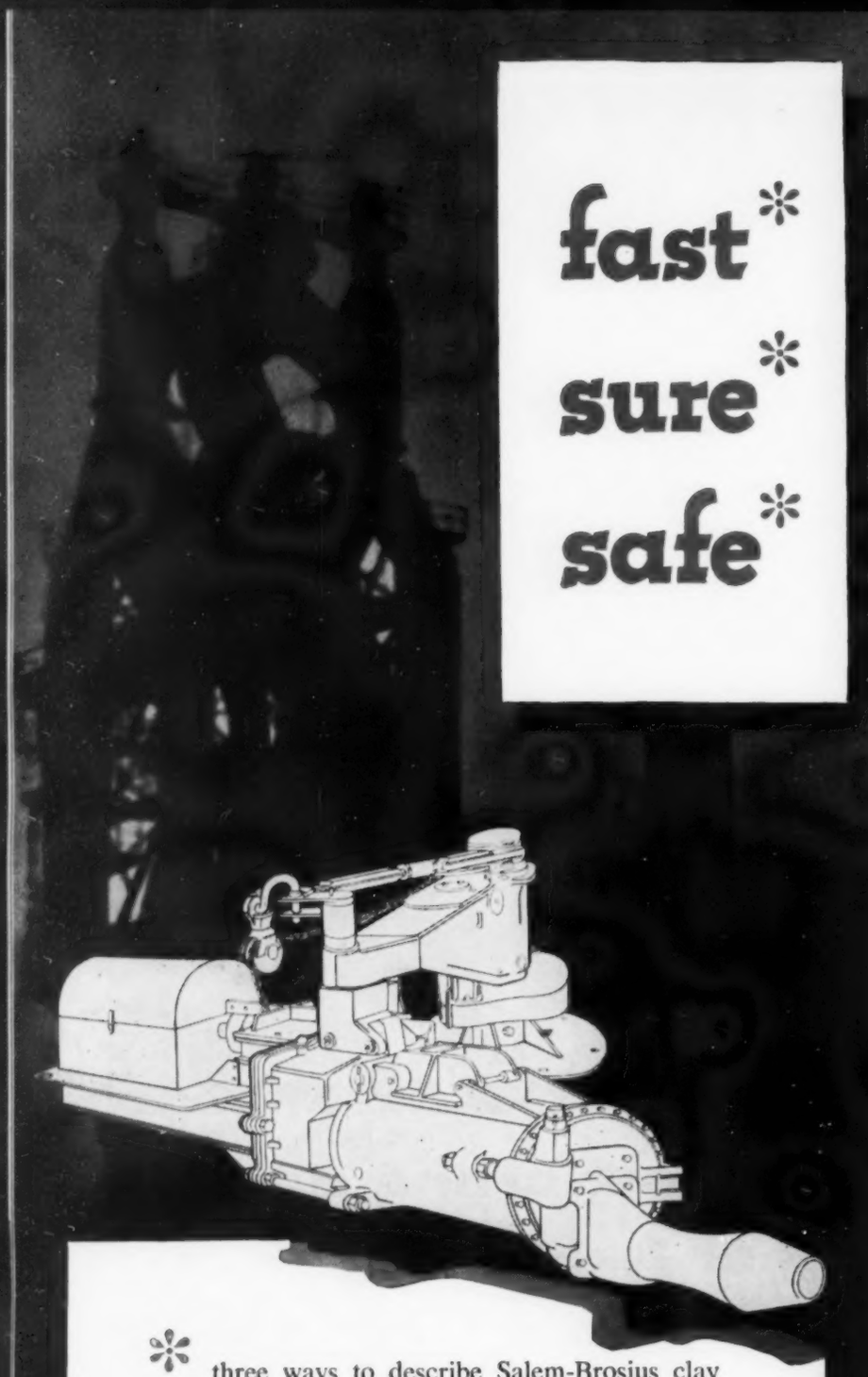
Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____



fast ✻ sure ✻ safe ✻

✻ three ways to describe Salem-Brosius clay guns in operation at the blast furnace tap hole. For more than three decades our engineers have diligently applied their experience to the design and production of efficient low-cost guns. That's why so many Salem-Brosius guns have been working so long—so well. Available mechanical, hydraulic, or steam—pedestal or column mounted. For fast, sure, safe guns—please write to us.

SALEM-BROSIUS, INC.

Aren Street, Carnegie, Pa.

In Canada: Salem Engineering Ltd.

1526 Bloor Street West • Toronto 9, Ontario

ACQUIRES CONTROLLING INTEREST IN ROCKBESTOS

▲ Consolidated Coppermines Corp. has acquired a controlling interest of approximately 84 per cent in Rockbestos Products Corp. through an exchange by a gorup of Rockbestos stockholders of their stock for shares of Consolidated Coppermines.

The acquisition of Rockbestos permits Consolidated Coppermines to enter the wire and cable field for the first time. It adds wire and cable manufacturing to the copper mining and metal fabricating operations as Consolidated Coppermines also owns a controlling interest in the Titan Metal Manufacturing Co. of Bellefonte, Pa., manufacturer of brass and bronze products.

It is intended to operate Rockbestos as a separate company under its present name, according to Chester D. Tripp, President of Consolidated Coppermines. Long-range plans call for expanding the Rockbestos operations, he said.

MOVE EXECUTIVE SALES OFFICE TO PITTSBURGH

▲ Establishment of executive and sales offices in the First National Bank Building, Pittsburgh, Pa. has been announced by Sutton Engineering Co.

Plant operation is to be continued at Bellefonte, Pa. where the firm has been manufacturing for more than 30 years.

A section of the Pittsburgh office was opened last year when extrusion presses and other hydraulic machines were added to the company line.

WESTINGHOUSE TO BUILD PLANT at YOUNGWOOD, PA.

▲ A new Westinghouse Electric Corp. plant, devoted to the manufacture of semi-conductor devices such as transistors, power rectifiers, high frequency detectors, and photocells, will be built at Youngwood, Pa.

The plant is scheduled for completion late this year, and will be operated by the company's newly-formed semi-conductor department. Manager of the new department and plant will be L. R. Hill.

The facilities ultimately will uti-

lize manufacturing equipment that is the most highly automatic of any in Westinghouse's 56 major manufacturing plants, according to Bruce D. Henderson, company vice president.

FINISHING FACILITIES ADDED AT FAIRLESS

▲ Additional facilities are being added to the sheet and tin finishing departments at U. S. Steel's Fairless Works. A single line ore sintering plant is also being constructed.

The sintering line will be used to recover flue dust, and will enable the sintering of some ore fines so as to improve the physical character of the material fed to the blast furnaces.

The new facilities are designed to increase the plant's production of hot and cold rolled sheets and tin plate to meet the expanding requirements of the eastern market areas.

OHIO STEEL FOUNDRY NAMES REPRESENTATIVE

▲ The Ohio Steel Foundry Co. announces the appointment of Frank B. Stauffer as its west coast representative. His office will be located in Oakland, Calif.

Mr. Stauffer will be responsible for the sale and service of rolling mill rolls, refinery fittings, and high alloy heat and corrosion resisting castings in the states of Calif., Ore., and Wash.

CELEBRATE ANNIVERSARY AND PLANT EXPANSION

▲ Mathews Conveyor Co. combined the celebration of its 50th anniversary with the completion of a million dollar expansion program at company headquarters in Ellwood City, Pa. The building program, started in January, 1954 and completed last month, involved a new three-story engineering and office building and two major additions to the plant, increasing manufacturing area by 30 per cent.

Additions to the manufacturing area involve a complete new truck shipping dock with hydraulically adjustable platforms, a greatly enlarged sheet metal department and area for the assembly of standardized belt conveyors, and a complete new build-

35% NICKEL

DURALOY

15% CHROMIUM

Furnace Castings

Here are two good examples of our work in high-nickel castings!

These are in the Duraloy HT group calling for Ni 33.37 percent. We've gone as high as 68% nickel on some castings where extremely high temperatures and very severe corrosive conditions had to be resisted. The important factor concerning castings for exceptionally high temperatures is that they must retain their structural form under load.

Knowing just how much nickel to put in and how much chromium and other alloying elements depends to a large extent on experience . . . and it is experience that we can offer you for the castings you need. We've been producing static castings since 1922 and centrifugal castings since 1933, being among the pioneer founders in each class.

If you would care to have our metallurgist study your casting problem, we shall be glad to have you call upon us for the service.

Our New General Catalog is yours for the asking.

THE DURALOY COMPANY

OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.
CHICAGO OFFICE: 332 South Michigan Avenue

REFRACTORY CEMENT

- BONDS STRONGER
- LASTS LONGER

For Example-

In Blast Furnaces—Because of its practically iron-free composition, Super #3000 shows exceptional resistance to carbon deposition and alkali attack. This plus its volume stability and great abrasion resistance make it the strongest refractory mortar for blast furnace work.

In Butt Weld Pipe Furnaces—Resetting fire brick arches and wash coating with Super #3000 has provided continuous service for many months, whereas other mortars failed in 5 to 6 weeks.

In Coke Ovens—Repairing floors while still hot with Super #3000 has saved one plant $10,000 in maintenance in a few months.

There are a great many more reports of Super #3000 success—where other refractory mortars have failed quickly and utterly—in furnace walls, arches and floors, soaking pits, sinter towers, ladle linings, etc. Users call it the "Wonder Cement." Try it—you'll agree.

REFRACTORY & INSULATION CORP.

R&I

REFRACTORY BONDING AND CASTABLE CEMENTS
INSULATING BLOCK, BLANKETS AND CEMENTS

136 WALL STREET • NEW YORK 5, NEW YORK

ing for the fabrication of heavy power conveyors. Both the new shipping area and the power conveyor assembly departments are equipped with new overhead cranes.

SALEM-BROSIUS OPENS NEW PLANT AND OFFICE

▲ Salem-Brosius, Inc. climaxed a five-year expansion and integration program June 24, formally opening a new headquarters plant and office building in Carnegie, Pa.

The new building brings all the firm's offices together under one roof for the first time since its founding.

The office building contains 27,000 sq ft of space, and is across the street from the manufacturing facilities.

MOVE HOUSTON OFFICE TO LARGER QUARTERS

▲ The Electric Controller & Manufacturing Co. announced the move of its Houston, Tex., district office to larger, more centrally located quarters in the Times Center Building, 2444 Times Blvd., Houston 5, Tex.

C. A. Mitchell will continue as district manager in the Houston area.

CF&I BROOKE FURNACE BACK IN OPERATION

▲ The Brooke Blast Furnace of the Colorado Fuel and Iron Corp. at Birdsboro, Pa., idle since May 20, 1954, was relighted June 9.

During the past few months the plant has undergone extensive reconditioning, including a complete relining of the blast furnace, the installation of a new pig casting machine, repairs to four hot blast stoves, five boilers and other auxiliary equipment.

Approximately 70 per cent of the plant's normal working force was employed during the reconstruction program.

TO CONSTRUCT CANADIAN SEAMLESS PIPE MILL

▲ Plans have been completed and a charter obtained for construction of Canada's first seamless steel pipe mill employing the automatic process, at Sault Ste. Marie, Ont., it was announced by the Mannesmann A. G., Duesseldorf, Germany.

The choice of leading mills for back-up roll bearings

. . . GULF I-C OIL

Several years ago Gulf I-C Oil was selected to lubricate the back-up roll bearings of the world's fastest cold strip mill at U. S. Steel's Fairless Works. Today it is still doing an outstanding job of providing effective protection as the strip shoots through the rolls at speeds up to 7000 feet per minute.

Gulf I-C Oil has excellent stability, resists emulsification and sludging, plus rapid water separating characteristics. These properties keep bearings and oil lines clean, contribute to longer bearing life, trouble-free performance, and lower maintenance costs.

So when you next order a roll-bearing lubricant, make it an order for dependable, efficient lubrication by specifying Gulf I-C Oil. Contact your nearest Gulf office and have a Gulf Sales Engineer recommend the proper grade for your equipment. Gulf Oil Corporation · Gulf Refining Company, 1822 Gulf Building, Pittsburgh 30, Pa.

GULF

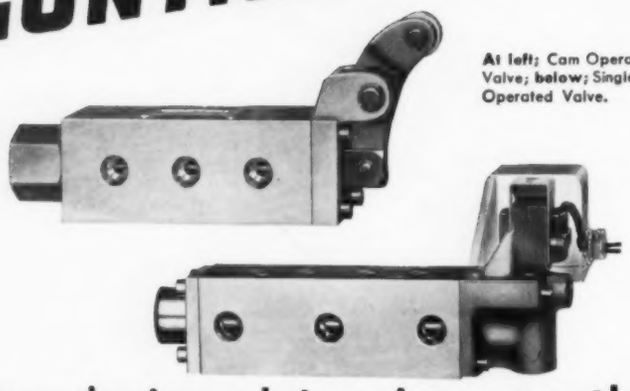
THE FINEST PETROLEUM PRODUCTS FOR ALL YOUR NEEDS

SELECT

Quick-As-Wink®

AIR AND HYDRAULIC

CONTROL VALVES



At left; Cam Operated Type "O" Valve; below; Single Solenoid Pilot Operated Valve.

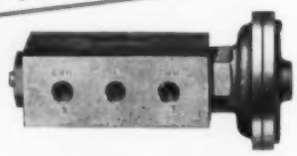
They're designed to give you the fast dependable trouble-free action you need

for single or sequence machine movements

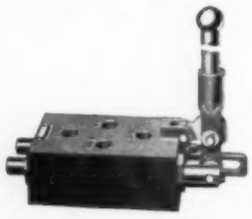
• Those successive and inter-related machine operations — that speed manufacture and cut costs — can only be as successful as the air and hydraulic valves that control the operations. Specify Quick-As-Wink Control Valves.

Positive and fast acting, Quick-As-Wink valves are designed and built to meet the most exacting requirements. They will deliver dependable and precision performance month after month, and year after year. Many superintendents and foremen have found that there is nothing better than a Quick-As-Wink valve. Can you afford to gamble with less? Get full details. Write for Bulletin No. 531 today!

Ask us also about . . .



DIAPHRAGM OPERATED "O-TYPE" VALVE, diaphragm can be actuated with instrument air as low as 12 to 15 psi.



LEVER OPERATED HYDRAULIC VALVE suited for water or hydraulic oils up to 5000 psi. 2-way, 3-way and 4-way actions.

Quick-As-Wink

AIR AND HYDRAULIC

Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1927 East Pershing St., Salem, Ohio

The new mill, a neighbor of the Algoma Steel Corp., which will supply its steel requirements, will primarily serve the needs of the fast-growing Canadian oil industry. Initially, the main products will be seamless casing and line pipe, also refinery pipe and mechanical hot finished pipe.

The mill will have several new features not incorporated in any of the existing pipe mills. It will have an annual rated capacity of about 225,000 tons.

The mill will begin operation late in 1956.

GE DIVISION ESTABLISHES BUFFALO SALES OFFICE

▲ Establishment of a new direct-sales office and warehouse in Buffalo, N. Y., has been announced by the General Electric Welding Department.

W. G. Leaman, Buffalo metallurgist and welding engineer, has been named manager of the new office, located at 701 Senaca Street. It is the regional outlet for the complete line of G-E equipment, electrodes and accessories.

McDOWELL CO. NAMES SALES REPRESENTATIVE

▲ H. Kleinhans Co., Pittsburgh, Pa., has been appointed sales representative in western Pa. for all of the enterprises now combined under McDowell Co., Inc.

As a McDowell agent, the firm will represent Dwight-Lloyd Division, Wellman Engineering Co., and the Williams Bucket, Locomotive Crane, and Anker-Holth divisions of Wellman.

Future Meetings

▲ A Joint Lubrication Conference will be sponsored by the Lubrication Activity Committee of the American Society of Mechanical Engineers, and the American Society of Lubrication Engineers at the Antlers Hotel, Indianapolis, Ind., October 10, 11 and 12, 1955.

There will be six sessions covering Bearing Instability, Recent Studies in Hydrodynamic Lubrication, Lubricants, Rolling Element Bearings, Boundary Lubrication.

it's OK let 'er go!

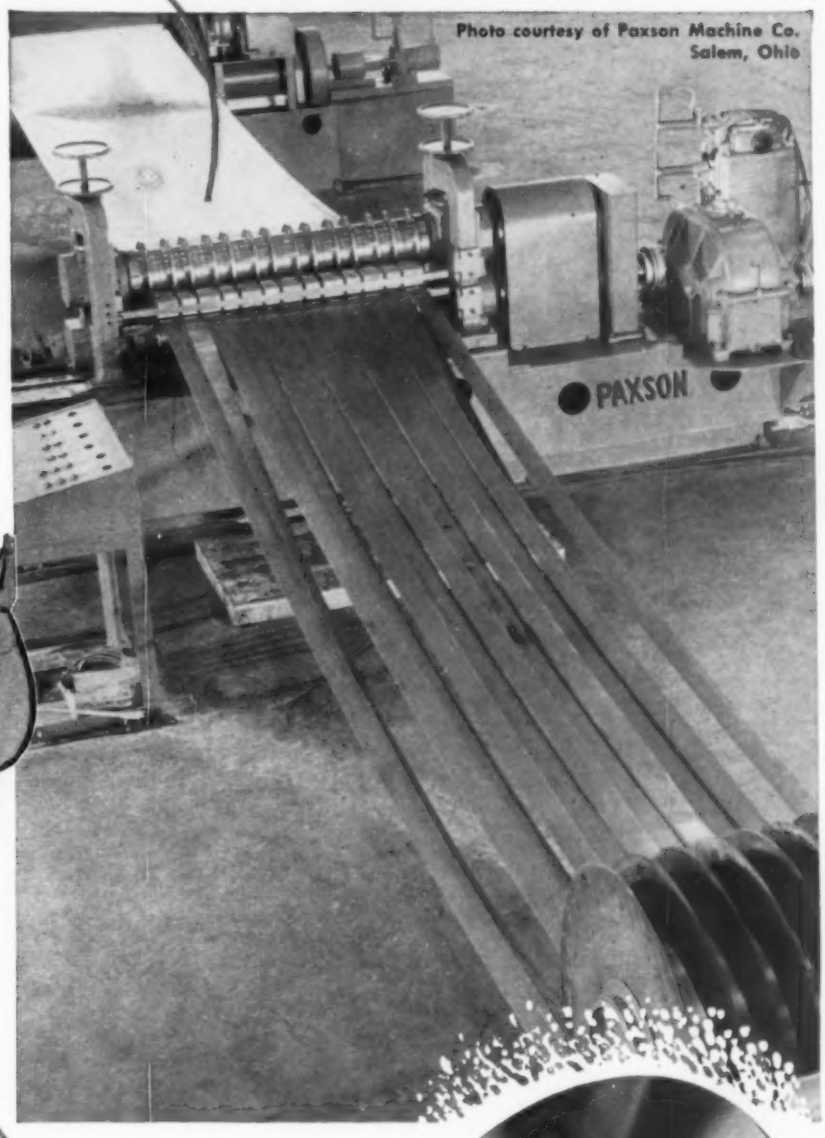
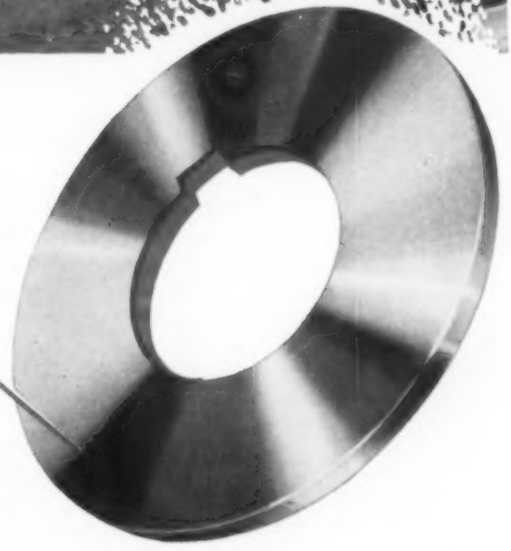


Photo courtesy of Paxson Machine Co.
Salem, Ohio



the gang's all here

. . . ready to knock down production costs—because OK Gang Slitter Knives run hour after hour without re-grinding giving you top machine productivity at all times. Here's why: exact metallurgical specifications for our steel—an exclusive heat treating process to give uniform hardness and temper —special grinding and finishing to tolerances of ± .00025 or finer.

Producers for the Metal Working Industry of:

SLITTER KNIVES • SHEAR BLADES • WORK-REST BLADES • CUT-OFF BLADES • SCRAP CHOPPERS • HARDENED SPACERS • HARDENED WAYS, GIBS, RACES

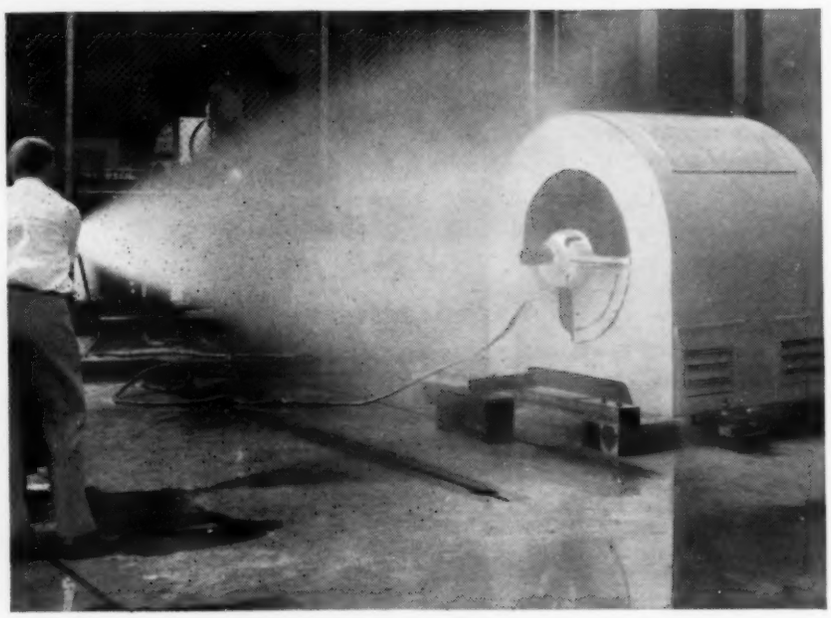
For free bulletin "SLITTING—A Basic Guide for the New Operator", write Dept. 21-Z

GO WITH OHIO GREEN

THE OHIO KNIFE CO.

CINCINNATI 23, OHIO

This 800-hp Westinghouse twin-motor drive operates the skin-pass mill work rolls in a 56″ tandem cold mill.



Tests like this prove Thermalastic's superiority. Water can be sprayed into the inlet openings while the motor is running. Immediately following, the coils successfully withstand three times the normal line-to-ground operating voltage.

"Out in the mill" operating conditions don't faze Westinghouse d-c motors

Dust, dirt, moisture, and similar mill atmospheres take a heavy toll of conventional d-c motors. That is why these motors are installed in a separate closed room, where possible. But, often, this is not the most desirable location from an operation standpoint. The best answer is to specify Westinghouse enclosed d-c motors... they are built to operate in most any contaminated atmosphere.

Thermalastic® insulation now available on large d-c motors

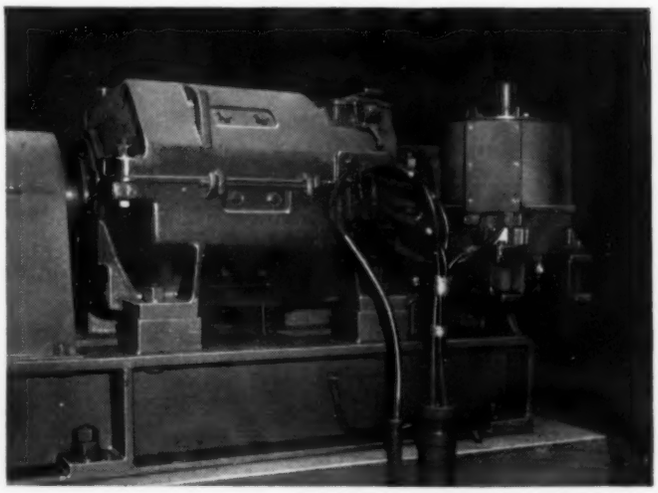
The same Thermalastic insulation that has proved its merit on large Westinghouse a-c motors is now being used on the full line of Westinghouse d-c motors above 250 hp. This is a mica insulation that has characteristics far superior to any ordinary insulation. An impregnating resin is used that is very stable chemically and has high moisture resistance. This, coupled with a high degree of fill achieved in the impregnating process, renders Thermalastic impervious to contamination from foreign elements.

D-c mill motors now provide easy access to brushholders

Whenever you locate a d-c motor in a contaminated atmosphere, you step up the maintenance required on commutator and brushes. That's why the new Westinghouse mill motor is built so that both top and bottom brushholders are accessible through the top openings. Access openings have been added in the lower half of the frame, also.

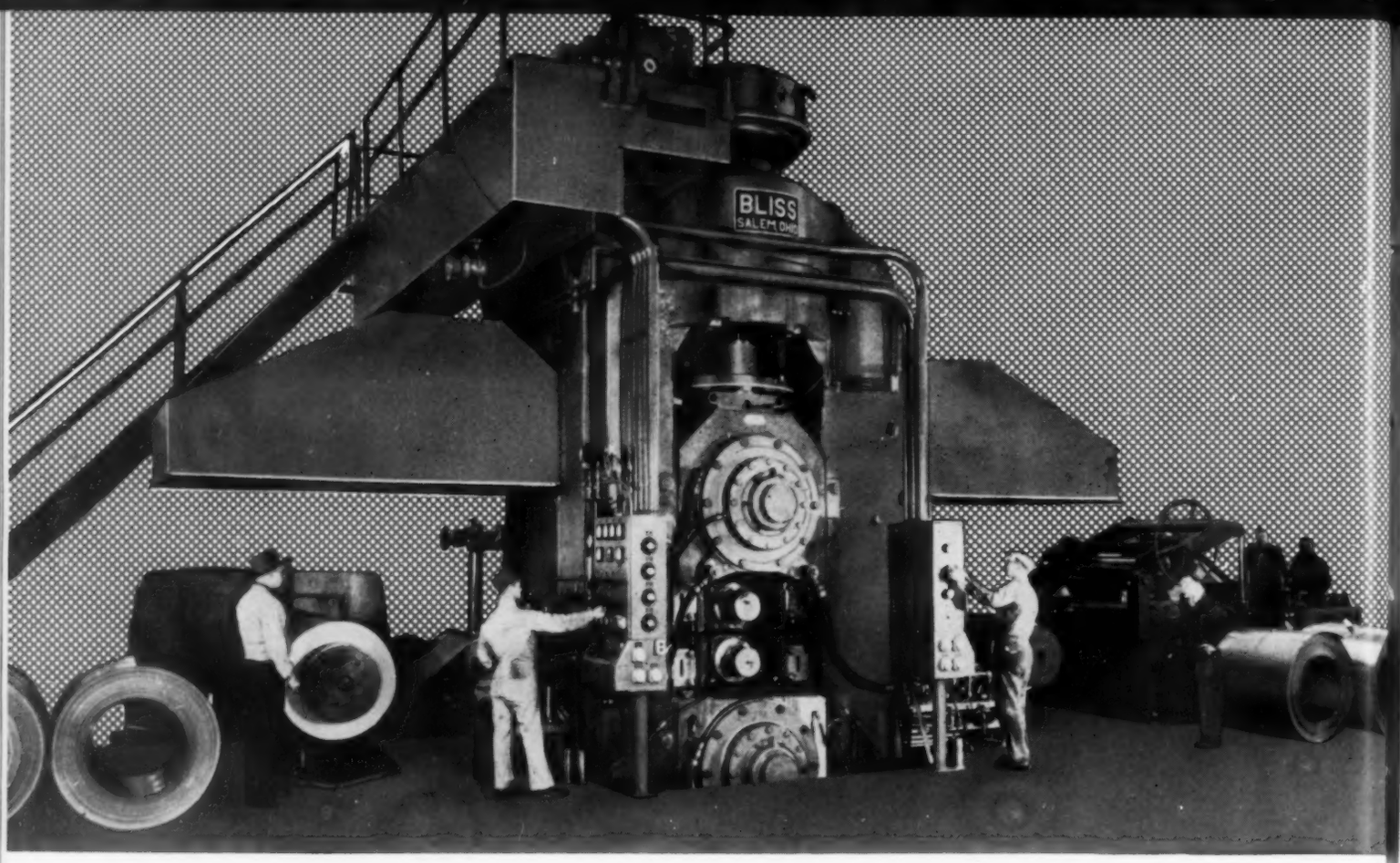
Ask your Westinghouse Man With The Facts about all the many other plus advantages you get when you install Westinghouse steel mill drives and steel mill auxiliaries. MP-3042

YOU CAN BE SURE... IF IT'S Westinghouse



This Westinghouse d-c mill motor with SA brake is driving a bar transfer machine in a bar mill. The motor is built to operate regardless of dust and dirt accumulation.

Remove the cover on any frame opening and you have ready access to the commutator and brushholder rigs. Brushholders are quickly removed by loosening the tap bolt.



Each minute...up to 1700 feet of cold rolled steel from

Newport Steel's New Bliss Cold Reversing Mill

This big Bliss mill has proved out "above expectation" in early test runs, and is now operating full time at Newport Steel Company's Newport, Kentucky, mill.

Working at speeds up to 1700 feet per minute, it reduces hot-rolled pickled strip in various gages and up to 48" widths. Its automatic coil handling equipment on both the entry and delivery end keeps pace with mill speeds, and is capable of handling coils up to 40,000 pounds.

Like all Bliss cold reversing mills, this Newport, Kentucky, installation is significant for its ease of operation. The mill is designed for fast changes, and centralized controls make possible virtually instantaneous adjustment while the mill is in operation.

This is just one of a complete line of Bliss rolling mills and accessories for both ferrous and nonferrous applications: two-high, four-high and cluster mills of Bliss manufacture are found in leading metal-producing plants throughout the world.

If you're interested in seeing how others have solved difficult cold and hot rolling problems, write for a copy of our recently revised Rolling Mill Brochure (Bulletin 40-A).

BLISS SINCE 1857 *is more than a name...it's a guarantee*

E. W. BLISS COMPANY
ROLLING MILL DIVISION, Salem, Ohio
Presses, ROLLING MILLS, Special Machinery

U. S. Plants in Canton, Cleveland, Salem and Toledo, Ohio; Detroit and Hastings, Michigan; San Jose, California; Pittsburgh and Midland, Pa. *Branch Offices in* Burbank, Chicago, Cleveland, Dayton, Detroit, Indianapolis, New Haven, New York, Philadelphia, Pittsburgh, Rochester, Salem, San Jose, Toledo, Washington, D. C.; and Toronto, Canada. *Other representatives throughout the world.*
E. W. Bliss (England) Ltd., Derby E. W. Bliss Co. (Paris), France

Personnel News...

James G. Cloyd has been named district industrial engineer for Republic Steel Corp.'s Chicago District steel plants. He succeeds **John W. Murchie,** who recently was made an assistant chief industrial engineer for the entire Republic organization. Mr. Cloyd has spent his entire career with Republic at its South Chicago steel plant. After working in various capacities in the open hearth department, he transferred to industrial engineering in 1941.

H. Stanley Thompson was appointed general superintendent of the A. M. Byers Co. South Side plant in Pittsburgh, Pa. He succeeds **Thomas Pritchard** who has retired. Mr. Thompson joined Byers in 1941 as plant metallurgist. He became general inspector in 1945 and was appointed assistant general superintendent on the first of this year. He previously had been connected with the Apollo Steel Co. Mr. Pritchard had been with the Byers Co. longer than any other employee. He began his career as an office boy in 1899 in Girard, Ohio, and has been connected with the company for 56 consecutive years. He was appointed assistant general superintendent of the firm's Girard Mill in 1923. He became general superintendent of that mill in 1927 and supervised the dismantling of the firm's properties in Girard, Ohio in 1930. He was appointed general superintendent of the South Side plant in 1936.

Edwin C. Ahrendt was appointed roll shop superintendent at Republic Steel Corp.'s Warren, Ohio, District steel plant. He succeeds **J. A. Lafferty,** who has retired after serving as superintendent for 27 years. Mr. Ahrendt worked in the engineering department of the Erie Railroad for three years before joining Republic in 1922. After a few months he was transferred to the No. 2 hot strip mill in Warren, which had just been installed, where he remained until his present appointment. In 1928 he was named night roller and in 1943 day roller. Mr. Lafferty was a roll turner for Page Steel & Wire Co. and Pittsburgh Steel Co., and a roll shop foreman for Weirton Steel Co. prior to joining Republic in 1928.

Fred H. Johnson, who formerly was assistant to the vice president of steel manufacturing at the Indiana Harbor Works of Inland Steel Co., was appointed engineering consultant to the vice president in charge of planning and administration. He will serve in a staff capacity, investigating and advising on technical problems arising from planning committee projects. Mr. Johnson was formerly chief engineer at the Harbor Works. Changes in the Indiana Harbor Works engineering department saw **S. W. Benson II,** formerly flat products engineer, appointed assistant chief engineer in charge of flat products and shape products engineering. **T. W. Myhre,** currently forward planning engineer, will become assistant chief engineer in charge of primary products, operating services and services engineering. **J. M. Howard** will continue as assistant chief engineer and will be in charge of mechanical, electrical, project and control engineering. Appointed to shape products engineer is **C. B. Pound,** now primary production engineer. **R. A. Hogue,** formerly senior engineer, primary mills, will become flat products engineer. **C. F. Kirkland,** currently senior engineer, open hearths, was made primary production engineer.

T. M. Girdler, chairman of the board of Republic Steel Corp., relinquished his duties as chief executive officer of the corporation. He will continue as chairman of the board of directors. **C. M. White,** president of the corporation, has assumed the duties of chief executive officer.

S. A. Ambler, has been promoted to general foreman of the continuous galvanizing department at the Pittsburgh Works Division of Jones & Laughlin Steel Corp. He formerly was assistant works industrial engineer at the Pittsburgh Works. **J. C. Hawkins,** formerly general metallurgical investigator, has been promoted to assistant general foreman. **D. W. Ferguson,** has been promoted to master mechanic of the new mill. He formerly served as assistant general foreman—electrical.

J. E. Anderson, formerly a member of Armco Steel Corp.'s research organization, has been named a staff maintenance engineer for the company. In his new position, Mr. Anderson will have staff responsibility for Armco's company-wide lubrication program, and

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A. J. MORGAN

will keep the operating organization advised of new developments in the lubricating field. He has been with Armco since 1937, when he joined the research laboratories as research assistant. He advanced to research assistant, junior research engineer, and research engineer. He was a senior research engineer at the time of his most recent advancement.

Oscar L. Maag joined the Ironsides Co. as consultant. He recently retired as research chemist and chief lubrication engineer of Timken Roller Bearing Co., after a 32-year career.

Wilbur H. Peter, Jr., formerly works manager of the Electric Controller & Manufacturing Co., has been elected vice president and works manager. Mr. Peter joined E. C. & M. in 1937, and served for seven years as a field engineer, working out of the company's Pittsburgh office. Returning to Cleveland in 1945 as supervisor of the company's Works Office he subsequently became manager of production control and personnel, and in 1951 was made production manager and shop superintendent. He has been works manager since June 1954.

John R. Smith has been appointed to the newly created position of product manager of distribution transformers of Pennsylvania Transformer Co. In other promotions, **Robert A. Dummer,** formerly engineer in charge of testing, succeeds Mr. Smith as factory liaison engineer; **John Zubenko** assumes the duties of testing engineer. As distribution transformer product manager, Mr. Smith will coordinate all engineering and production activities relating to the company's "Pole Star" distribution transformers.

A. J. Morgan has been appointed sales manager of sheet and strip equipment for the Aetna-Standard Engineering Co. He joined Aetna-Standard's engineering department in 1936. In 1940 he became proposal engineer for the company's flat rolled division. In 1952 he was appointed assistant sales manager of sheet and strip equipment.

T. H. Hagan has been appointed general superintendent of Republic Steel Corp.'s Southern District. He was formerly superintendent of steel works at Gadsden, Ala. In his new position he will supervise all operations at both the Gadsden and Birmingham plants. He came to Gadsden as combustion engineer for the Gulf States Steel Co., a Republic predecessor. In 1940 he became general foreman of the sheet mill and in 1944 was made superintendent of that department. He was named superintendent of steel works in 1953.

Frank F. Elliott, senior vice president of sales for Crane Co. since 1952, has been elected president and chief executive officer of the company. He succeeds **John L. Holloway,** who resigned as president and director because of ill health. Mr. Holloway, who was elected president in 1946, will continue as a consultant to the company.

Bert L. Wood, who has served as consulting engineer of the American Iron and Steel Institute since October, 1938 will retire October 1. He will be succeeded by **William G. Kirkland** who joined the staff of the Institute in 1947 and served as resident engineer in the western states. Mr. Wood has served the steel industry for more than 40 years, and is a nationally recognized authority on building construction standards and fire protection regulations. He will continue with the Institute in an advisory capacity as a part-time consultant.

Bruce D. Henderson, vice president of Westinghouse Electric Corp., has been appointed to the apparatus products staff and **A. M. Kennedy, Jr.,** has been appointed general manager, purchases and traffic, succeeding Mr. Henderson. Since 1952 Mr. Kennedy has been assistant general manager of purchases.

Thomas E. Williams, in addition to his present duties as superintendent of the Los Angeles, Calif., steel service plant of Joseph T. Ryerson & Son, Inc., has been appointed general superintendent of the company's West Coast plants on a staff basis, reporting to the assistant vice president in charge of operations. Mr. Williams began his career with Ryerson at its Chicago

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plant in 1923. Moving to Buffalo, N. Y., he became superintendent of the plant there and was transferred to Los Angeles in a similar capacity in 1946. He returned to Chicago, Ill., as operating superintendent in 1950. He remained in Chicago four years before resuming the post of superintendent of the Los Angeles plant.

Ellis J. O'Brien has been appointed manager, standard products sales of Heyl & Patterson, Inc. Mr. O'Brien joined the company in 1952, and was chief development engineer for the company at the time of his taking the sales position. Prior to joining Heyl & Patterson, Mr. O'Brien was associated with the Vanadium Corp. of America as a process metallurgist both in the United States and South America.

Allan R. Rowen, former sales manager of Sintering Machinery Corp.'s lightweight aggregate division, has been employed by McDowell Co., Inc. as a sales engineer and head of the lightweight aggregate section of the firm's new Dwight-Lloyd Division. Mr. Rowen helped develop the first Dwight-Lloyd sintering plant for producing lightweight aggregate from shale.

Ralph B. Kraft has been appointed company representative in the Chicago district for the Alliance Machine Co.

E. W. Adams has been appointed plant manager of Kaiser Aluminum & Chemical Corp.'s new basic refractory brick plant, soon to be constructed at Columbiana, Ohio. Mr. Adams was formerly assistant to J. F. Knight, manager of operations, chemicals division.

James K. Sutherland has been elected executive vice president of the Sun Steel Co. Mr. Sutherland will make his headquarters in Sun Steel's new Detroit office in the Buhl Building.

Ray W. Knapp is now associated with the Schmutz Manufacturing Co., Inc. of Louisville, Ky. He will direct the development, design, and sales engineering in marking and printing applicable to the steel industry. Mr. Knapp was formerly with The Pannier Corp.

George C. Betz has been appointed manager of sales, Chemical and Metals Department, Metal & Thermit Corp. In his new post he will manage sales activities for the company's industrial chemicals and plating materials, ceramic products and metals and alloys. Mr. Betz has been associated with Metal & Thermit since 1944 as sales manager of the ceramics department. He was previously assistant general manager of Star Porcelain Co., and prior to that assistant sales manager of Foote Minerals Co.

Charles B. Buker has been appointed supervisor–product technical services, strip mill and tin mill products section of the Technical Services Division of Jones & Laughlin Steel Corp. **Lewis U. Davis** has been appointed supervisor–product technical services, hot rolled, cold finished, wire, and tubular products section

Arthur H. Osborne has been appointed service engineer on the headquarters staff of the technical division of Armco International Corp. Mr. Osborne joined Armco in 1929, in the metallurgical department at Armco's Middletown Works.

Paul A. Mori was named vice president—operations of the Cleveland Quarries Co. Mr. Mori has been superintendent of the Amherst quarries operations since 1940 and has been an employee of the company for 42 years. In March of this year he was elected a member of the Board of Directors of the company.

Samuel M. Felton has been appointed president of the American Car and Foundry Division of ACF Industries.

J. W. Banks has been made assistant blast furnace superintendent for the Thomas furnaces of Republic Steel Corp.'s Birmingham, Ala., plant. He is being transferred from the Youngstown District where he first joined Republic in 1946. Since 1952 he has been assistant general foreman of blast furnaces at Youngstown, Ohio.

J. D. Dickerson was appointed to the staff of the central operating department of Crucible Steel Co. of

ELLIS J. O'BRIEN

ALLAN R. ROWEN

RALPH B. KRAFT

E. W. ADAMS

America, with headquarters in Pittsburgh, Pa. Mr. Dickerson had been chief metallurgist at the company's Midland, Pa., Works. Also, **C. S. Walton,** former staff metallurgist, has been named to succeed Mr. Dickerson as chief metallurgist at Midland.

Wallace E. Nyce, manufacturing manager, Exide Industrial Division of the Electric Storage Battery Co., retired June 30 after 43 consecutive years with the company.

L. G. Murray was appointed manager of Aetna-Standard Engineering Co.'s export sales. Mr. Murray joined Aetna-Standard in 1937 in the engineering department. During World War II, he moved to the Ord-

L. G. MURRAY

nance Department where he designed gun mounts for anti-aircraft guns. After the war he supervised installation of equipment for Aetna-Standard's Flat Products Division.

Thomas G. Lewis, a veteran of 30 years with the Youngstown Sheet and Tube Co., has been appointed assistant to the director of purchases.

George F. Groff has been appointed secretary of Crucible Steel Co. of America. In assuming his new responsibilities, Mr. Groff will continue in his present office of vice president-finance.

Donald E. Moat was named assistant director of marketing of the Leeds & Northrup Co. Formerly district sales manager in the Leeds & Northrup Cleveland, Ohio office, he will be acting head of the marketing department here, succeeding the late **L. E. Emerich.**

Edward T. Lewis, formerly sales representative for the J. H. France Refractories Co. in western N. Y. and northeastern Pa., has been appointed district sales manager for territories including Canada, western N. Y. and northeastern Ohio. **James F. Myers,** formerly sales representative for the company in northwestern Pa. and Canada has been named district sales manager for zonal territories covering western Pa., southeastern Ohio and W. Va. **Oliver H. Smith,** formerly a sales representative for the company in New England and the East has been appointed Eastern District sales manager.

James L. Oberg has joined Metal & Thermit Corp., in the capacity of technical advisor. In his new position Mr. Oberg will work with all departments on projects

JAMES L. OBERG

involving manufacturing processes, and will investigate new markets and new uses for existing products as well as potential new products of a metallurgical nature. He has been associated with The Babcock & Wilcox Co. for the past fifteen years.

Keith G. Splude was named divisional sales manager of the Brake Division of Stearns Magnetic, Inc. Mr. Splude, formerly an application engineer at the Louis

KEITH G. SPLUDE

Allis Co., will be responsible for the sale and service of the company's complete line of magnetic brakes and small clutches.

R. L. Williams, district manager of the Timken Roller Bearing Co.'s St. Thomas, Ontario office, has been named district manager at the new Columbus office. **B. C. Price** has been named district manager at St. Thomas. **L. H. Gegenheimer,** assistant district manager in Cleveland, has been named district manager to replace **J. W. Weir** who has retired.

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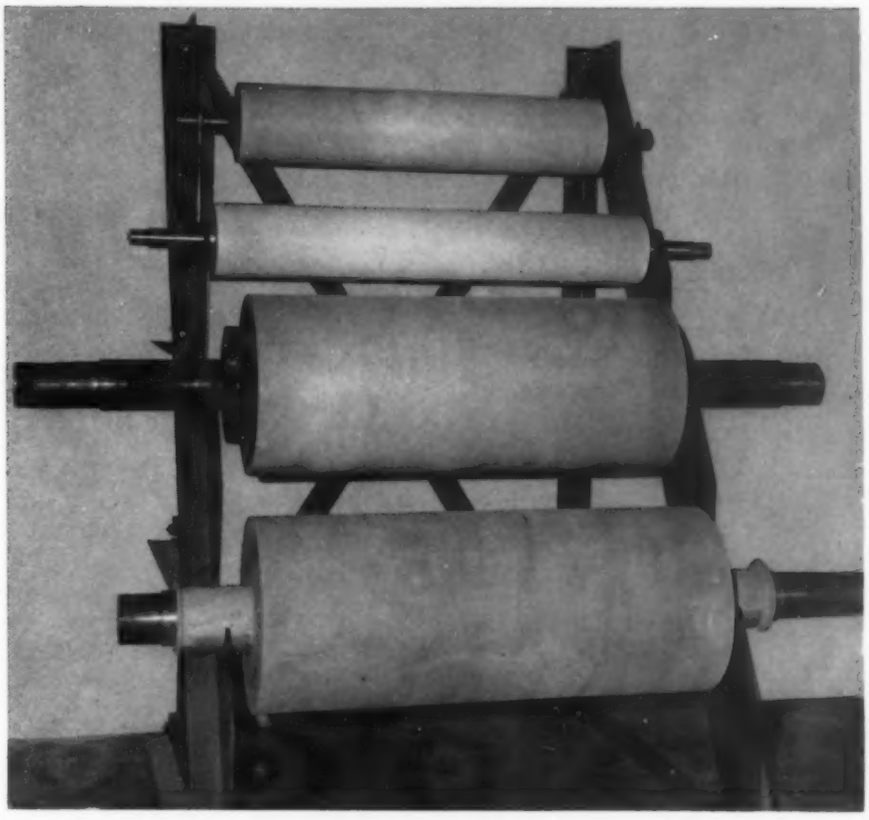

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Obituaries

George M. Carvlin, 55, vice president and general manager of the Engineering and Construction Division of Koppers Co., Inc. since 1952, was fatally injured in an auto accident June 12. Mr. Carvlin joined Koppers Research Department at Kearny, N. J., in 1925. Several years later he was transferred to the Pittsburgh offices of the Co., and in 1931 became associated with Koppers Engineering and Construction Division. He became a vice president in the division in 1943 and assistant general manager in 1950.

Rhodes D. Swinburne, comptroller, Wheeling Steel Corp., died on June 16.

Rufus E. Zimmerman, retired vice president and chairman of the research policy committee, U. S. Steel Co., died June 21. He was 68. Dr. Zimmerman first became associated with steel research in 1914 when he joined the American Sheet and Tin Plate Co., which later became a part of U. S. Steel. In 1915 he was made assistant director of research laboartory of American Sheet and Tin Plate and was made acting director of research in 1917. He became director of research in 1919 and assistant to vice president in 1922, a position which he held until 1932. In that year he went to New York as assistant to president of United States Steel Corp. being made vice president in 1933.

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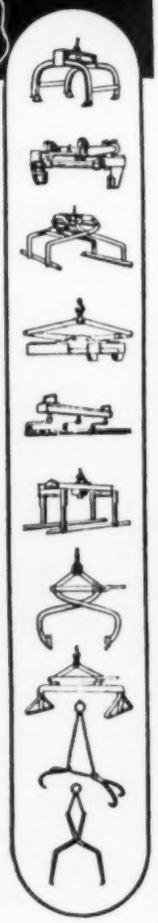

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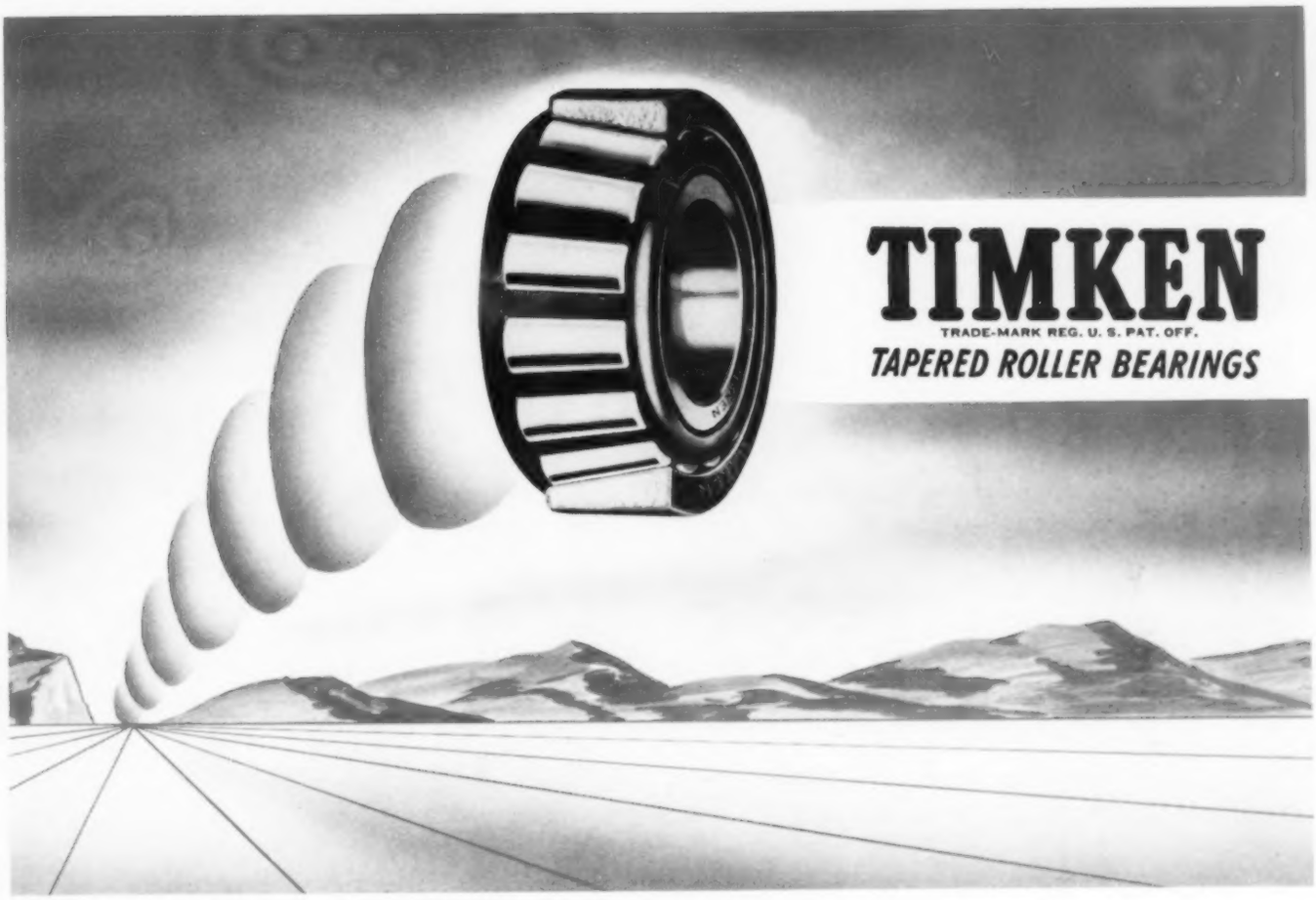

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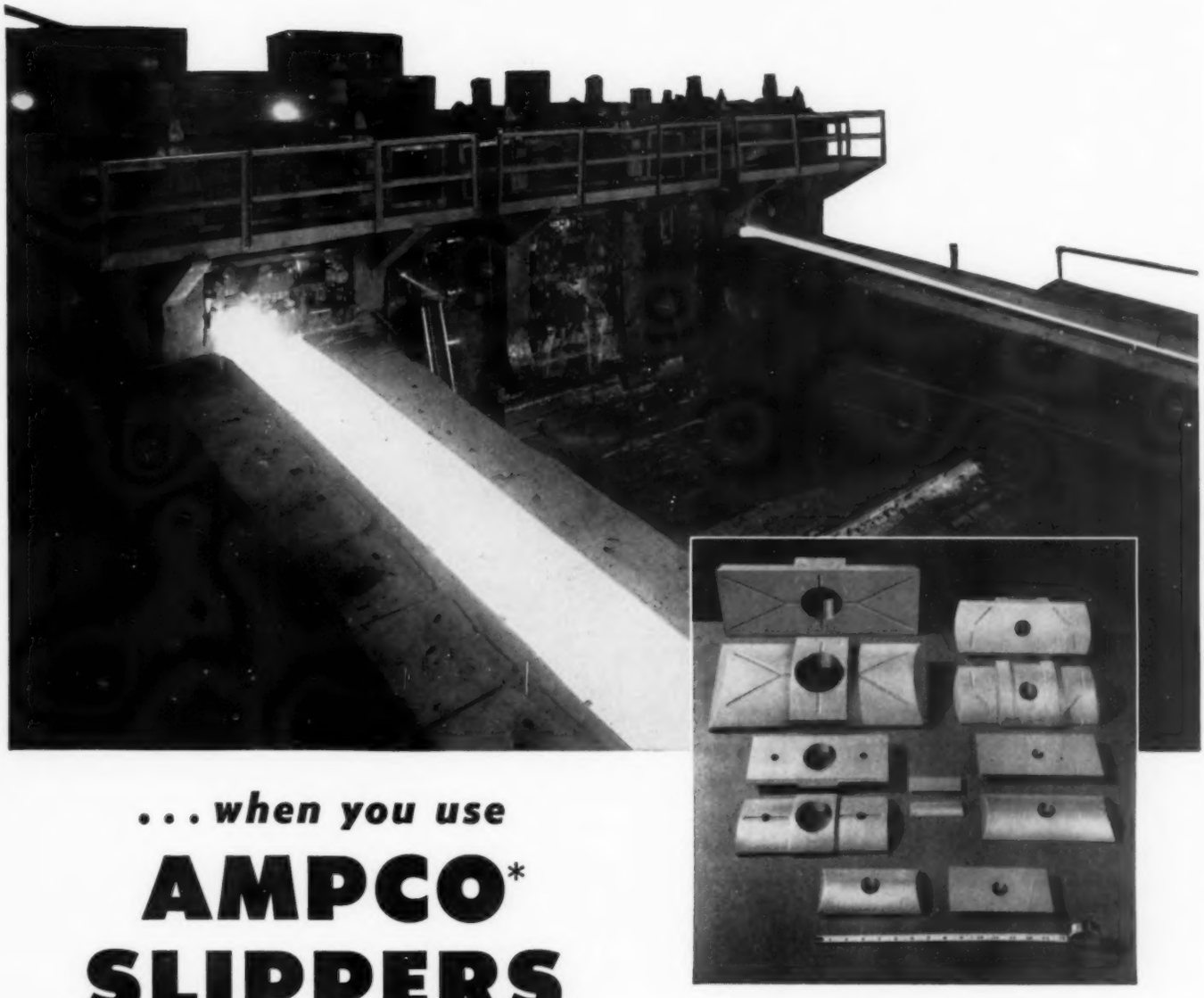

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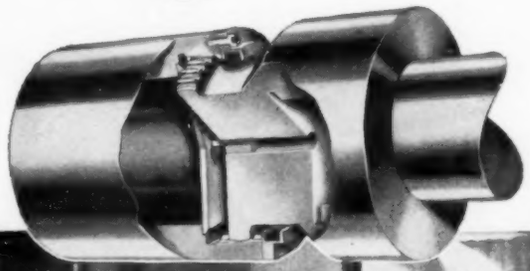

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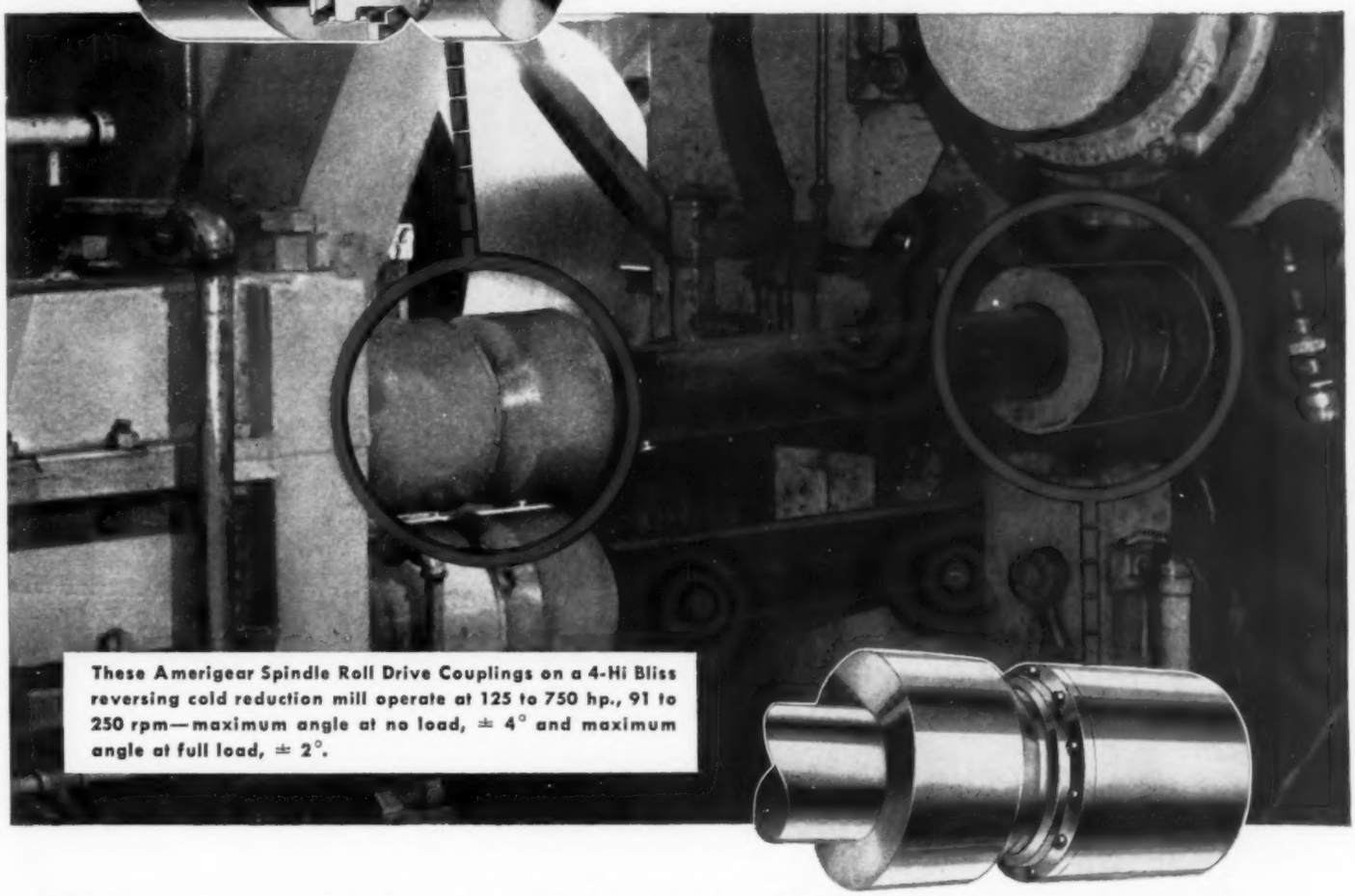

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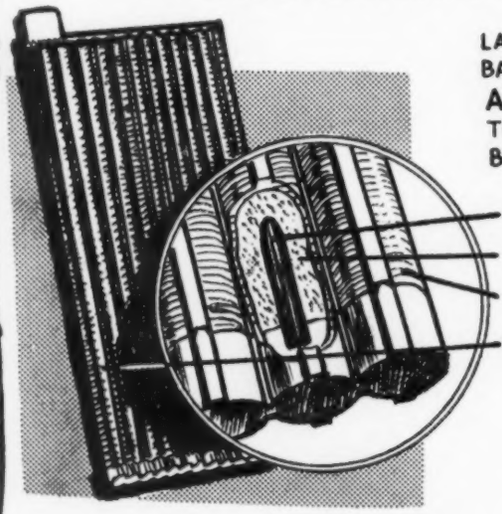

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EXIDE-IRONCLADS ARE YOUR BEST POWER BUY **AT ANY PRICE!**

LET EXIDE HELP SOLVE YOUR INDUSTRIAL TRUCK BATTERY PROBLEMS ❶ CALL AN EXIDE SALES ENGINEER FOR FULL DETAILS ❷ WRITE FOR FORM 1982, A MANUAL ON INSTALLING AND MAINTAINING MOTIVE POWER BATTERIES

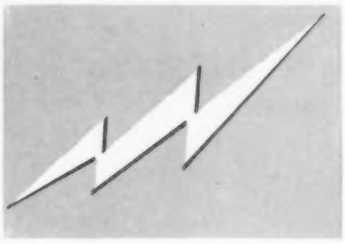
Exide INDUSTRIAL DIVISION, The Electric Storage Battery Company, Philadelphia 2, Pa.

NEWS IN TEMPERATURE MEASUREMENT AND CONTROL!

HAGAN MODEL "P" AMPLIFIER SETS NEW RECORDS FOR

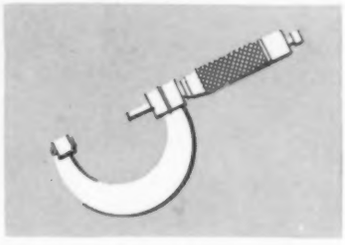
SPEED

FULL SCALE RESPONSE IN 0.1 SECOND



ACCURACY

PLUS OR MINUS ¼% OF INPUT RANGE

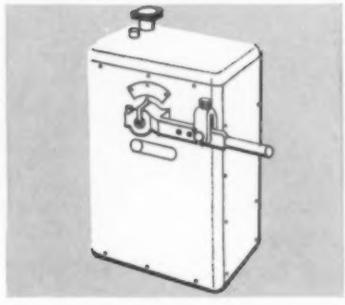


LOW MAINTENANCE

NO SLIDE WIRES — NO REVERSING MOTORS

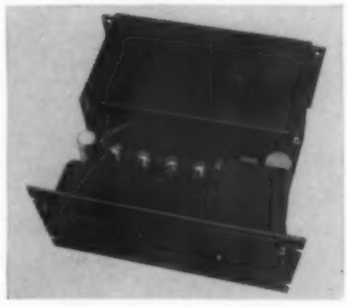
CONTROL

WITH HAGAN ELECTRO-PNEUMATIC CONVERTER



The Hagan PowrAmp Model "P" DC Amplifier boosts over-all steel plant efficiency by making possible more precise temperature control. Use the Model "P" to *record* and *control* temperature of soaking pits—open hearths—heating furnaces—blast furnaces.

Because of its feedback stabilized circuit and its drift-free linearity, the Model "P" provides the steel plant operator with a new and highly efficient method of temperature measurement and control.



HAGAN POWRAMP
MODEL "P" DC AMPLIFIER

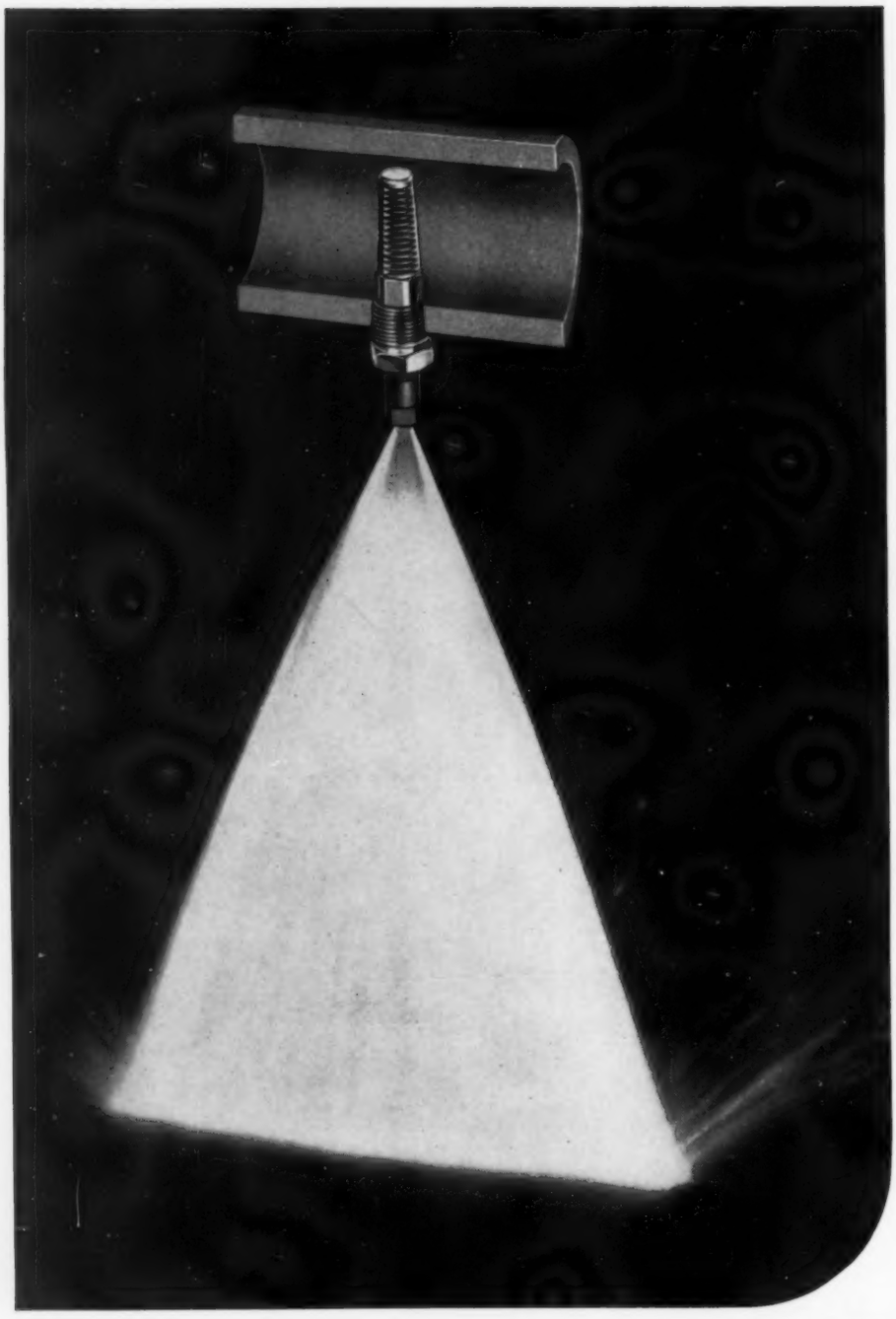
Send for Hagan Bulletin MSP-111.1 for the full story on this versatile and money-saving instrument.

HAGAN HALL BUROMIN CALGON

HAGAN CORPORATION

HAGAN BUILDING · PITTSBURGH 30, PENNSYLVANIA

Metallurgical Furnace Control Systems · Control Systems for Aeronautical and Automotive Testing Facilities · Boiler Combustion Control Systems · Ring Balance Flow and Pressure Instruments



SPRAYING SYSTEMS

descaling NOZZLES

with open, elliptical non-clogging orifice

for performance *in full measure*

you can SEE the difference

When you consider performance in all its aspects, here are spray nozzles for descaling that give outstanding full measure. Descaling itself is carried out with an efficiency as high as or higher than any other nozzle made. But equally important, Spraying Systems nozzles give you low first cost . . . **plus non-clogging design** that **reduces** the cost of down-time and maintenance to a minimum.

The thin, concentrated, uniform spray strikes with greatest possible impact for any volume and pressure . . . descales without excessive sheet cooling.

Clogging is practically eliminated by *elliptical*-shaped orifice . . . foreign matter goes right through.

CHOICE OF SIZES . . . offered in 16 different capacities . . . for every known descaling use.

Designed and manufactured by America's leading producers of industrial spray nozzles. For complete information write for Data Sheet 6120.

SPRAYING SYSTEMS COMPANY 3262 Randolph Street • Bellwood • Illinois

Spray Nozzles also supplied for such applications as Run-Out Table Cooling . . . Roll Cooling . . . Cooling Ingot Molds and many other uses. For complete information write for Catalog No. 24.

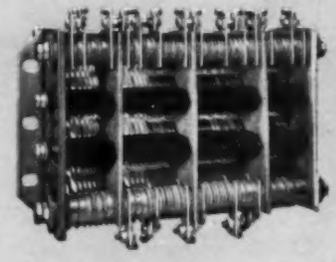
P-G the ORIGINAL

Steel Grid Resistor

plays an essential part in the production of steel

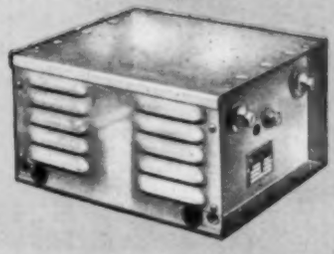
Built for severe service conditions
Protects vital electrical equipment
Constant "trouble free" performance
Quick adjustments easily made

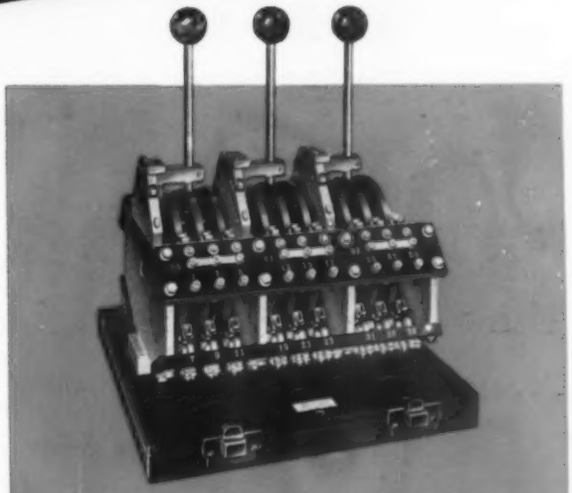
P-G Resistors for Internal Mounting in Face Plate Controllers



Standard Units for 2 to 25 H. P. Motors. Also supplied for external mounting.

P-G Resistors for
SAFETY LIMIT STOPS
Available in standard units for any size motor.





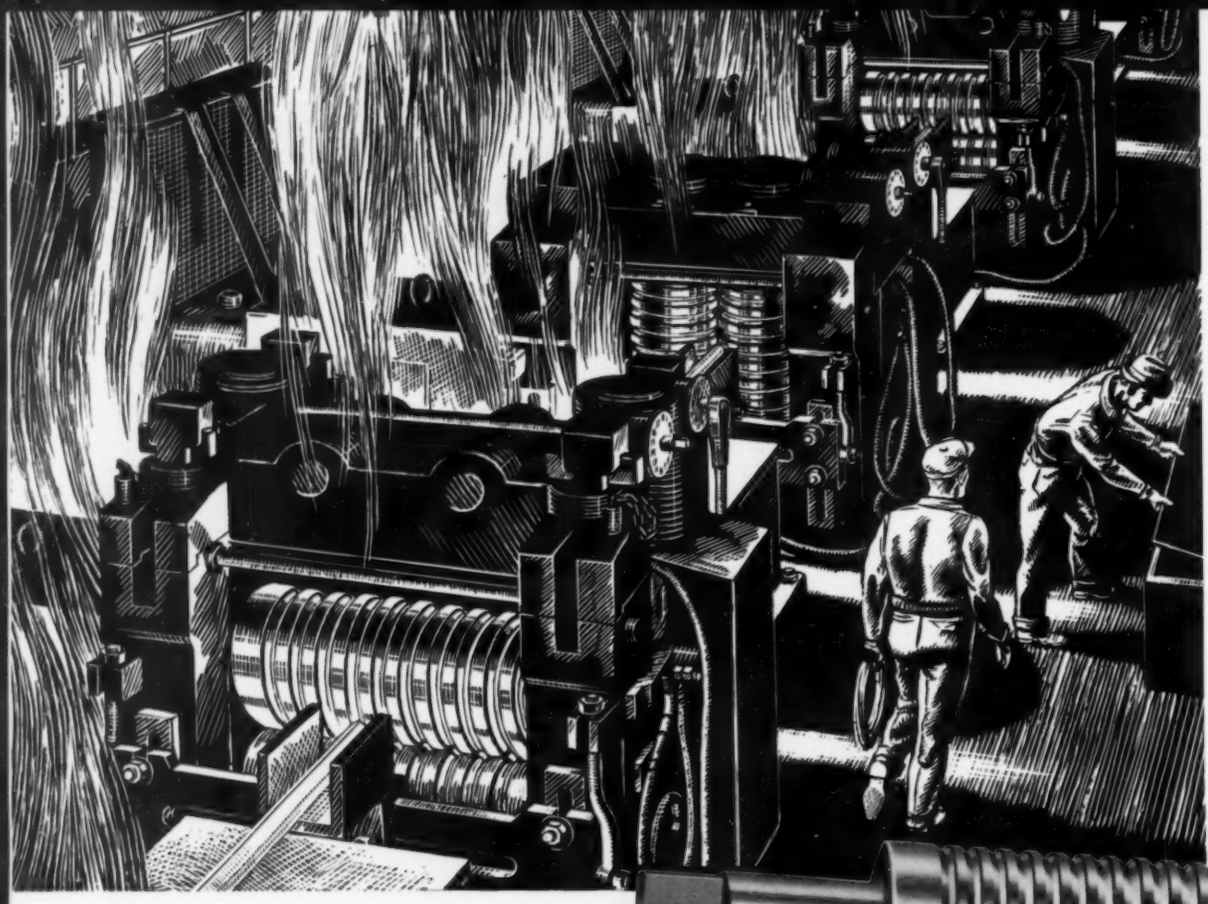
P-G Type MD **Master Switch**
for general application in Mill Service

Save valuable mounting space . . . One to four switches in a single enclosure . . . Overall length less than 22" on four-unit Switch.

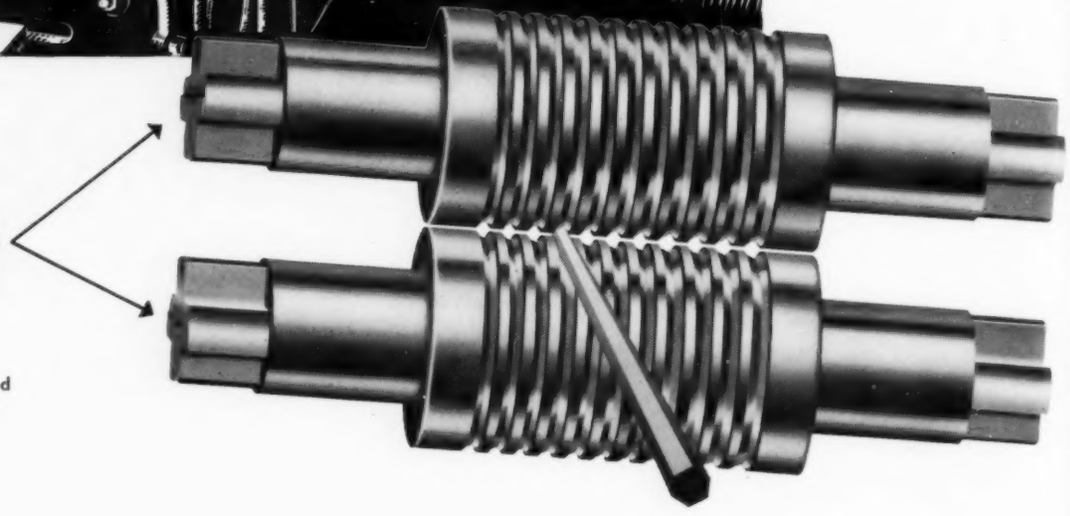
P-G

Send for Bulletins

THE POST-GLOVER ELECTRIC COMPANY
• ESTABLISHED 1892 •
221 WEST THIRD STREET, CINCINNATI 2, OHIO



Our Rolls are color marked
for specific applications



The right roll in the right stand
... *assures faster delivery speed*
... *longer roll life*

Our roll engineers are always available to help you with your engineering, design and application problems. Their practical experience and technical know-how are your assurance of proper roll selection for any application in your mill.

PITTSBURGH ROLLS

BLAW-KNOX

BLAW-KNOX COMPANY • ROLLS DIVISION • PITTSBURGH ROLLS DEPARTMENT
PITTSBURGH 1, PENNSYLVANIA

PITTSBURGH ROLLS: Chill • Sand • Moly Chill • Special Rail Finishing • Phoenix "K" • Sandaloy • Pittsburgh 25 • Pittsburgh 35 • Pittsburgh 45 • Pittsburgh 55 • Pittsburgh Special Process • Phoenix 25 • Phoenix 35 • Phoenix 45 • Phoenix 55 • Phoenix Special Process • Phoenixloy • Phoenix Metal • Phoenix Metal Special • Phoenix Metal "F" • Phoenix Metal Master • Carbon Steel • Phoenix "A" • Phoenix "A" Special • Piroco • Piroco "A" • Piroco "B" • Piroco Special • Herculyte

Equipment News...

STRAIGHTENER

▲ A new guideless tube and bar straightener has been introduced by the Sutton Engineering Co.

This new design, titled "KTC," employs a total of seven straightening rolls. One group of three rolls is mounted at the entry end of the machine and another group of three rolls at the delivery end of the machine. Each roll group is composed of one large driven roll and two idler rolls disposed at an angle of approximately 120 degrees to each other. Located between the two 3-roll groups is a middle idler roll which serves the purpose of deflecting the pipe during the straightening operation.

This unique roll arrangement eliminates the use of all guides and at the same time positively confines the bar or tube to the pass line throughout the straightening operation. Positive feeding of all material and uniform straightening from end to end are also assured.

Another advantage of the straightener is apparent in the straightening of oil country goods where the collapse strength of the material is an important factor. By surrounding the pipe with three rolls a minimum of ovality is introduced in the tube between the cross rolls. This factor in conjunction with the reduced amount of cross roll pressure required in the machine permits a considerable reduction in the loss of collapse value normally experienced in cross roll straightening.

A feature of the straightening unit is the automatic roll angling device. As the machine is set for stock size by means of power operated screw-downs, all rolls except the middle pressure roll are automatically adjusted to the proper angularity for the size of bar or tube being straightened. The middle pressure roll is manually adjusted for angle by means of two accessible handwheels. Automatic angling of the rolls plus the power operated screw-downs makes possible extremely rapid size changes. For example, to change from straightening 5 in. O.D. to straightening 14 in. O.D. tubes requires less than two minutes.

Straightening speeds normally vary between 60 to 240 fpm using a 200 hp, 300/1200 rpm adjustable speed d-c motor. Production speeds, however, can be altered to suit individual requirements.

FLYING PRESS

▲ Developed by Wean Equipment Corp., is a new stamping and shallow draw press with great operating speed as its objective.

The Wean Flying Press eliminates the necessity for starting and stopping the feed of coiled steel. This moves at a continuous speed through the press at all times, and the upper and lower dies move forward and synchronize with this speed during the time in which the stamping is performed, thereby greatly increasing the number of parts that can be made each minute and giving much greater accuracy to the length which is fed into the press. The production here will reach as high as 600-900 strokes per minute.

In addition to great speed, the press has other advantages — principally in the matter of maintenance and downtime. A conventional press uses a clutch and brake to actuate the ram of the press, and these two units must work every time the press makes a stroke. Seventy per cent of all press maintenance is generally found in these two items. The Flying Press has neither clutch nor brake. It has no flywheel as such, but stores its energy in the motion of the dies and die holders, thereby applying the latent stored energy right at the place of work rather than at the end of an overhung shaft, as in the conventional press.

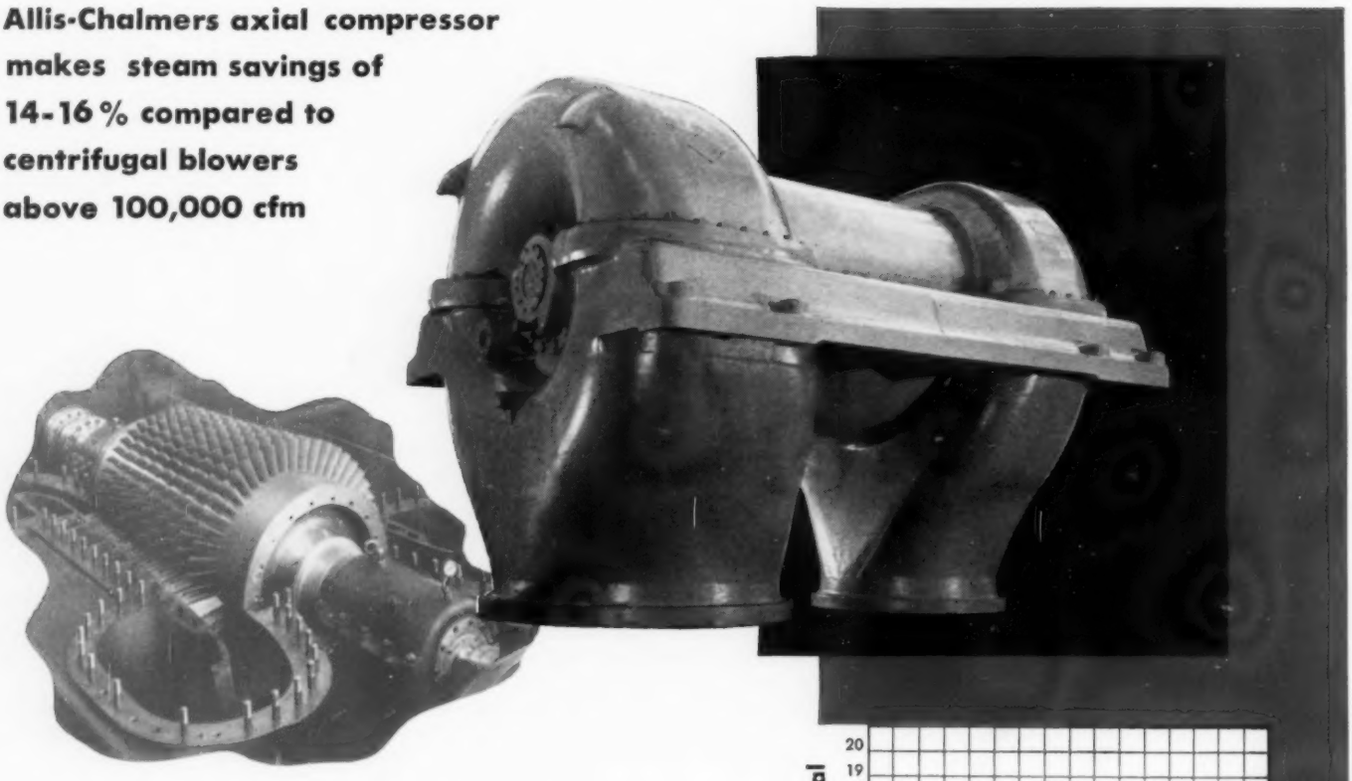
Because the strip never stops as the speed gets greater, the velocity of the completed part becomes greater and is ejected from the press with greater and greater ease as the speed increases.

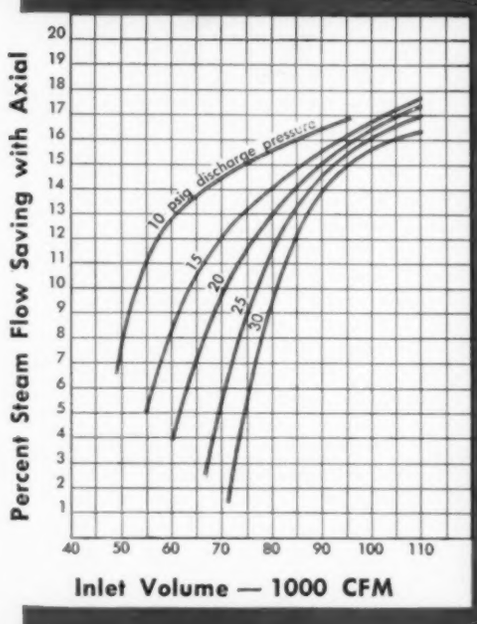
The Wean Flying Press has been designed as a packaged unit. All controls necessary for operation are in the stainless steel panel on the side of the machine. The press will be built in a number of different size ranges.

Blast Furnace Operators Can

Save to $50,000 a Year on Steam

Allis-Chalmers axial compressor makes steam savings of 14-16% compared to centrifugal blowers above 100,000 cfm





Three factors combine to provide outstanding savings:

1. Higher efficiency of axial compressor. This advantage is inherent. Air path in axial is nearly a straight line. Losses due to sharp turns (as in multi-stage centrifugal blowers) are eliminated.

2. Higher turbine efficiency. At 100,000 cfm and above, the speed of an Allis-Chalmers axial compressor approaches the optimum speed of 3600 rpm. In contrast, the speed of a centrifugal blower drops to 2600 or 2700 rpm. This higher design speed results in higher turbine efficiency — added steam flow economy for the axial compressor.

3. Steam condenser required is smaller.

Axial compressors are also smaller, easier to install. They require less floor space, smaller foundations than centrifugal blowers of the same rating.

Unbiased Recommendations

Allis-Chalmers builds both axial and centrifugal types. Whatever your blower problem, call your nearby A-C office, or write Allis-Chalmers, Milwaukee 1, Wisconsin. A-4731

A-C ALLIS-CHALMERS

ALLIS-CHALMERS

SPLICING TAPE

▲ Announced by the Okonite Co., is a new line of cable splicing tapes for use with standard steam or electric vulcanizers. Known as Okonite Vulcanizer Tapes, the complete line includes rubber insulation, rubber sheath and colored neoprene sheath tapes that are simple to apply and vulcanize easily into void-free splices equal mechanically and electrically to the cable itself.

Developed originally to withstand the rough treatment given portable cables, these tapes may be used wherever the immediate, added protection of a vulcanized splice is desired in permanent or fixed cable installations. These tapes are compounded for maximum electrical strength and mechanical toughness and are supplied in a standard one-in. width for easy application.

The rubber insulation tape is grey and the rubber sheath tape is black. The neoprene sheath tape is available in black, red, yellow and green for simplified identification and color-coding. All colors provide the lasting protection of an abrasion and moisture-resistant neoprene sheath that can be permanently bonded to the neoprene sheath of any cable.

MOTORS

▲ Newly designed standard and explosion-proof totally enclosed motors featuring corrosion-resistant cast iron frames, improved winding insulation and heavy duty ball bearings have been developed by Wagner Electric Corp.

Grease fittings are provided at top and bottom of bearing housing to permit convenient lubrication and removal of old grease. A running shaft seal on each end of fan-cooled motors and on the drive end of non-ventilated motors effectively prevents the entrance of moisture, dirt and other contaminants which might injure the bearings. Pressure-cast aluminum squirrel-cage rotors are dynamically balanced to assure smooth, quiet operation.

Current production includes ratings 1 through 10 hp, 4 pole, 60 cycles in rerated NEMA frames 182 through 256U. Frames 213 and larger are cast with heavy ribs for efficient cooling. A smooth-running, external fan of

Look Overhead . . . see "NORTHERN"

For heavy, continuous service in steel storage yards

The 40-ton, 75-foot span, heavy duty crane shown above is typical of many similar NORTHERN CRANE installations in steel mills, fabricating plants, and similar plants in heavy industry.

NORTHERN mill type cranes are designed and built to meet the most exacting requirements, providing for continuous service, maximum loads, and high impact allowances. Mill type motors and control equipment provide highest electrical performance.

NORTHERN CRANES are the result of over 55 years' experience in the design of overhead electric traveling cranes, heavy duty electric hoists and other materials handling equipment.

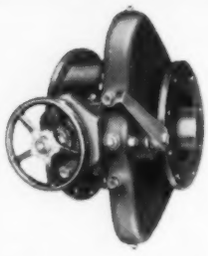
Let us send you our latest bulletins

NORTHERN | MATERIALS HANDLING EQUIPMENT

NORTHERN ENGINEERING WORKS
210 CHENE ST., DETROIT 7, MICH.

Bailey
GOGGLE
VALVES

For shutting off gas mains from 6″ to 72″ in diameter, these valves are the means to complete safety, complete dependability. Whether they are used every day or as infrequently as once a year, they open or close instantly. A tight, sure seal is provided by a clamping force applied equally at all points around the disc periphery. The same powerful mechanism frees the goggle plate.



If desired, Bailey Goggle Valves may be totally enclosed. Both types—open and enclosed—require only a minimum of maintenance.

WILLIAM M. Bailey COMPANY
ENGINEERS
LEADERSHIP THROUGH QUALITY
1221 BANKSVILLE ROAD PITTSBURGH 16, PA.

bronze or malleable iron effectively cools the motor and prevents dust from collecting on the frame. The flow of air is directed around all sides of the motor by a protective cast iron shield. Smaller ratings are totally-enclosed, non-ventilated.

VALVE HEADS

▲ New solenoid valve heads have been developed by Hannifin Corp.

These solenoid covers are die cast of zinc alloy and gasketed so that the valve becomes splash-proof and dust tight. Each cover is chained to the valve so it cannot be mislaid. It is held in place by four "captive" screws which do not fall out of their holes in the cover when loosened.

In addition, at the end of each cover is a manual operating button which can be operated with a small screwdriver or even with a pencil to provide manual operation of the valve without removing the cover. This operating button is sealed with an "O" ring so as not to impair the splashproof, dust tight feature.

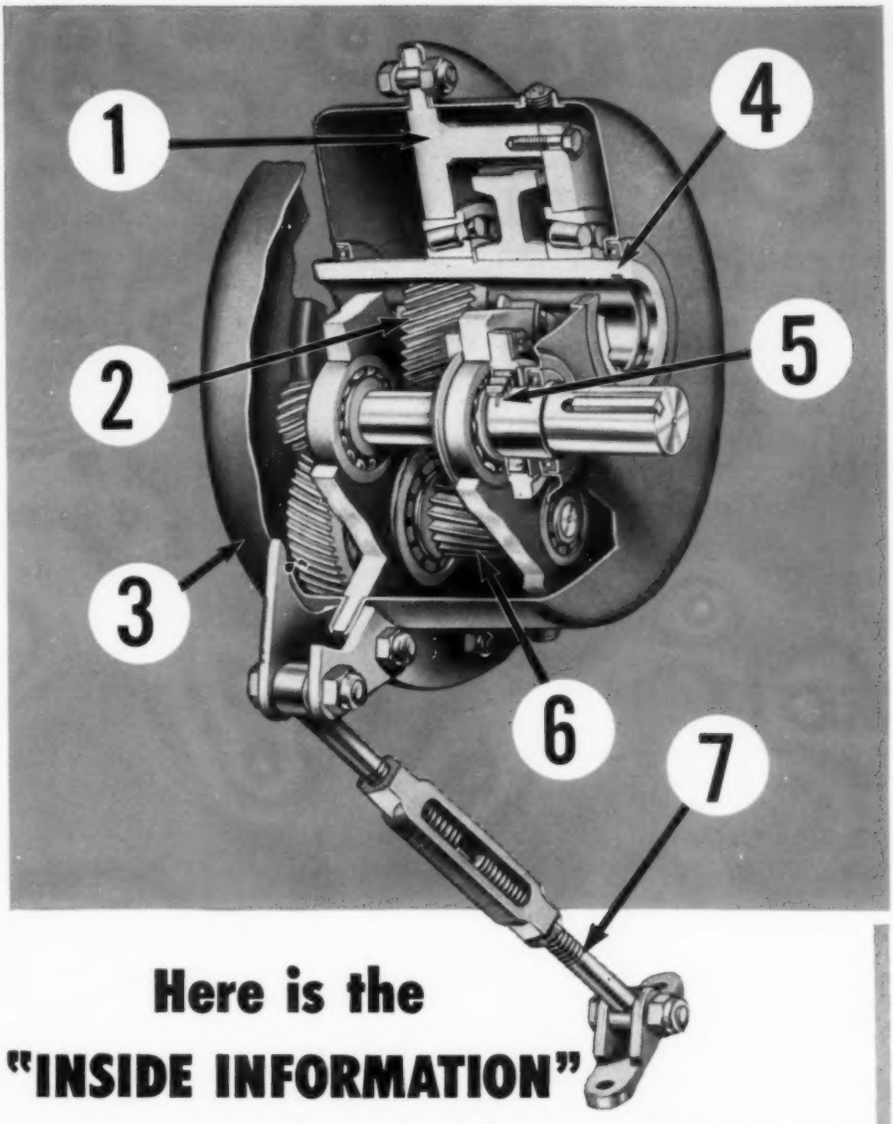
TRANSFORMER

▲ Development of a metallically sealed, gasketless distribution transformer has been announced by Pennsylvania Transformer Co. All bushings, the cover, and a stem for oil-filling and pressure-testing are permanently sealed in place by metal-alloy fusion, and there are no handholes or other means of access to the tank. When placed in production, the transformers will be available, without taps, in 5, 10, 15, and 25 kva sizes, 2400 through 14,400 volts.

According to the manufacturer, the chief advantage of the new transformer—which bears the trade name "Perfect Seal Pole Star"—will be to eliminate the limited "breathing" which ultimately may develop in present-day gasketed transformers, particularly when the units are opened and then resealed by users.

The transformer is made with no nuts or bolts inside the tank. "All electrical connections are brazed or crimped, and all internal mechanical connections are welded, soldered or riveted.

One of the most important design aspects of the permanently sealed distribution transformer is that the



Here is the "INSIDE INFORMATION" on FALK ALL-STEEL Shaft Mounted Drives

Take a careful look inside the Falk all-steel Shaft Mounted Drive, and you will know why this newest member of the famous Falk family is ideal for applications where direct mounting on the driven shaft is desirable. It is the only drive in its field with all these superior "In-built" factors:—

1 **All-steel Frame,** with more than double the rigidity of iron, supports all rotating elements.

2 **Precision Helical Gears,** designed and machined by Falk, rated to AGMA standards.

3 **Pressed Steel Housings,** whose sole function is to keep oil in, dirt out; easily removed for gear inspection without dismounting unit.

4 **Through Hollow Shaft** with counter bore provides for easiest installation or removal from driven machine shaft extensions.

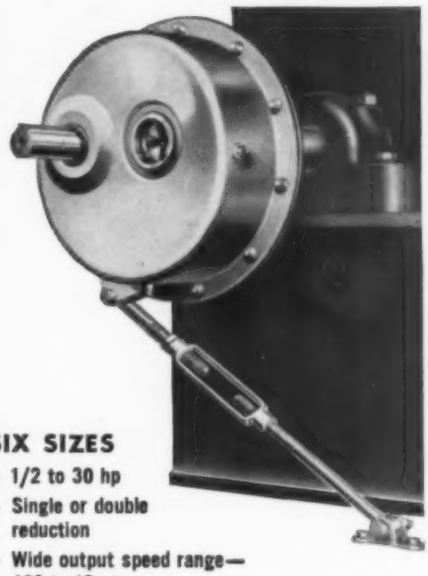
5 **Backstop** can be furnished with the unit or added later for positive prevention of reverse rotation.

6 **Positive Lubrication,** continuous direct dip of revolving elements at all speeds.

7 **Tie Rod** and turnbuckle serve as anchor and facilitate V-belt or chain adjustment.

Write to Department 247 for engineering bulletin, including selection and dimension details.

EFFICIENT SPEED REDUCTION IN LIMITED SPACE

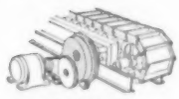


SIX SIZES

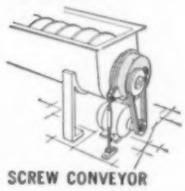
- 1/2 to 30 hp
- Single or double reduction
- Wide output speed range—420 to 10 rpm

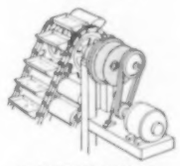
Expressly designed for topflight performance on installations requiring considerable speed reduction in limited space, the all-steel FALK Shaft Mounted Drive has quickly won acceptance throughout industry. This sturdy, compact, versatile reducing unit is an ingenious variation of the highly successful FALK Motoreducer design, pacemaker in its field for more than 20 years. Here, the time-proved design is adapted for mounting directly on the shaft to be driven, using V-belt connection to motor. Investigate now!

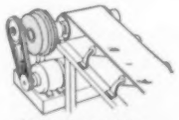
A FEW TYPICAL APPLICATIONS

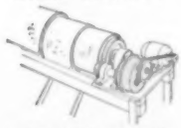

APRON FEEDER

LINE SHAFTING


SCREW CONVEYOR


BUCKET ELEVATOR


BELT CONVEYOR


GRAVEL CLASSIFIER

THE FALK CORPORATION, Milwaukee 8, Wisconsin

MANUFACTURERS OF

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

FALK

...a good name in industry

—a leading manufacturer of pile driving and extracting equipment

"For many years we have used LUBRIPLATE Lubricants for shop assembly, and have recommended them to our customers through your LUBRIPLATE Tag Plan. Our experience shows that if the proper lubricants are used from the beginning, there are fewer problems and parts replacements later. We consider LUBRIPLATE to be the best possible ounce of prevention."—
H. G. Warrington, Vice-Pres.

REGARDLESS OF THE SIZE AND TYPE OF YOUR MACHINERY, LUBRIPLATE GREASE AND FLUID TYPE LUBRICANTS WILL IMPROVE ITS OPERATION AND REDUCE MAINTENANCE COSTS.

LUBRIPLATE is available in grease and fluid densities for every purpose... LUBRIPLATE H. D. S. MOTOR OIL meets today's exacting requirements for gasoline and diesel engines.

For nearest LUBRIPLATE distributor see Classified Telephone Directory. Send for free "LUBRIPLATE DATA BOOK"... a valuable treatise on lubrication. Write LUBRIPLATE DIVISION, Fiske Brothers Refining Co., Newark 5, N. J. or Toledo 5, Ohio.

cover (with bushings in place) and the core-and-coil assembly are permanently joined together to form an integral unit, which is lowered into the tank. The cover then is permanently sealed to the tank by metallic fusion, and oil is added through an oil-filling stem in the cover. A cap is welded onto the stem after pressure tests have been conducted.

The final design of all kva and voltage classes had not been definitely determined, but it is now believed that all bushings will be cover-mounted. Production of the permanently sealed units is expected to begin within the next six months.

STARTERS

▲ A new line of high voltage starters with new 400 amp current limiting fuses, completely new air break contactors, and all new sheet steel enclosures has been developed by Westinghouse Electric Corp.

The starters have ratings of up to 1500 hp at 2300 volts and 3000 hp at 5000 volts for both induction and synchronous motors, and can be applied on power systems having a maximum fault capacity of 150,000 kva at 2300 volts or 250,000 kva at 5000 volts.

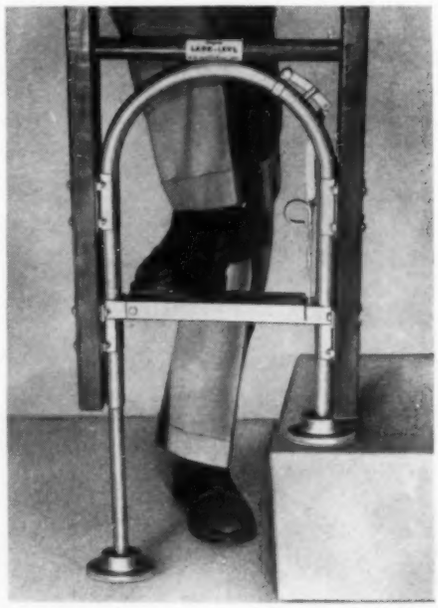
The new 400-ampere fuse is a single unit with a single mounting. The fuse not only limits fault current but interrupts in less than one-half a cycle.

The new air-break contactor in ratings of 200 and 400 amperes is capable of interrupting 50,000 kva at either 2300 or 5000 volts. Arc boxes are hinge-mounted to permit easy access to arcing contacts without removing other parts. The new enclosures, built to a standard depth of 60 in., are much narrower than previous designs, reducing width as much as 46 in. in some instances. Mechanical interlocks between both oil immersed and air break contactors and the fuse compartment door assures greater personnel safety.

LADDER ATTACHMENT

▲ A safety device that demonstrated in exhaustive tests that it eliminates most of the accidents commonly associated with the use of ladders, has been developed by H-B Industries, Inc.

Patented under the name of "Ladr-Levl," it is easily attached to any ladder, wooden or metal. Its self-adjusting legs adapt themselves to any terrain, no matter how uneven, and permit the ladder to stand upright securely. Slipping is prevented by non-skid, swiveling feet. For use on stairways or steps, its legs take a full 9½ in. riser.



When the user puts his weight on the first rung, the mechanism locks automatically in place, and can be unlocked only by hand.

The weight of the ladder is always directed downward along the side rails, eliminating lateral stresses. The device can be easily installed, and can be transferred from ladder to ladder. It pays for itself because it increases ladder life by eliminating lateral stresses. It eliminates makeshift, unsafe leveling devices, such as wood blocks or bricks, and does away with the need of a second man to hold the bottom of the ladder.

The unit is manufactured to a minimum 1000 lb ladder load test.

REFRACTORY COATING

▲ A new line of pure oxide refractory coatings which have commercially proved their ability to protect metal parts from higher temperatures has been announced by Norton Co.

These coatings are of two types: aluminum oxide coatings on a wide range of base materials, particularly metals, and silicon carbide on graphite base materials.

Aluminum oxide coatings are applied in a molten state by means of

Why TIMKEN® thrust bearings last longer

WHEN steel meets mandrel in the piercing mill at Youngstown Sheet and Tube Company's Campbell Works, the steel has to give. A Timken® thrust bearing takes the terrific pressure that's exerted on the mandrel. And Timken bearings in these thrust blocks can take it as proven by 20 years of continued use.

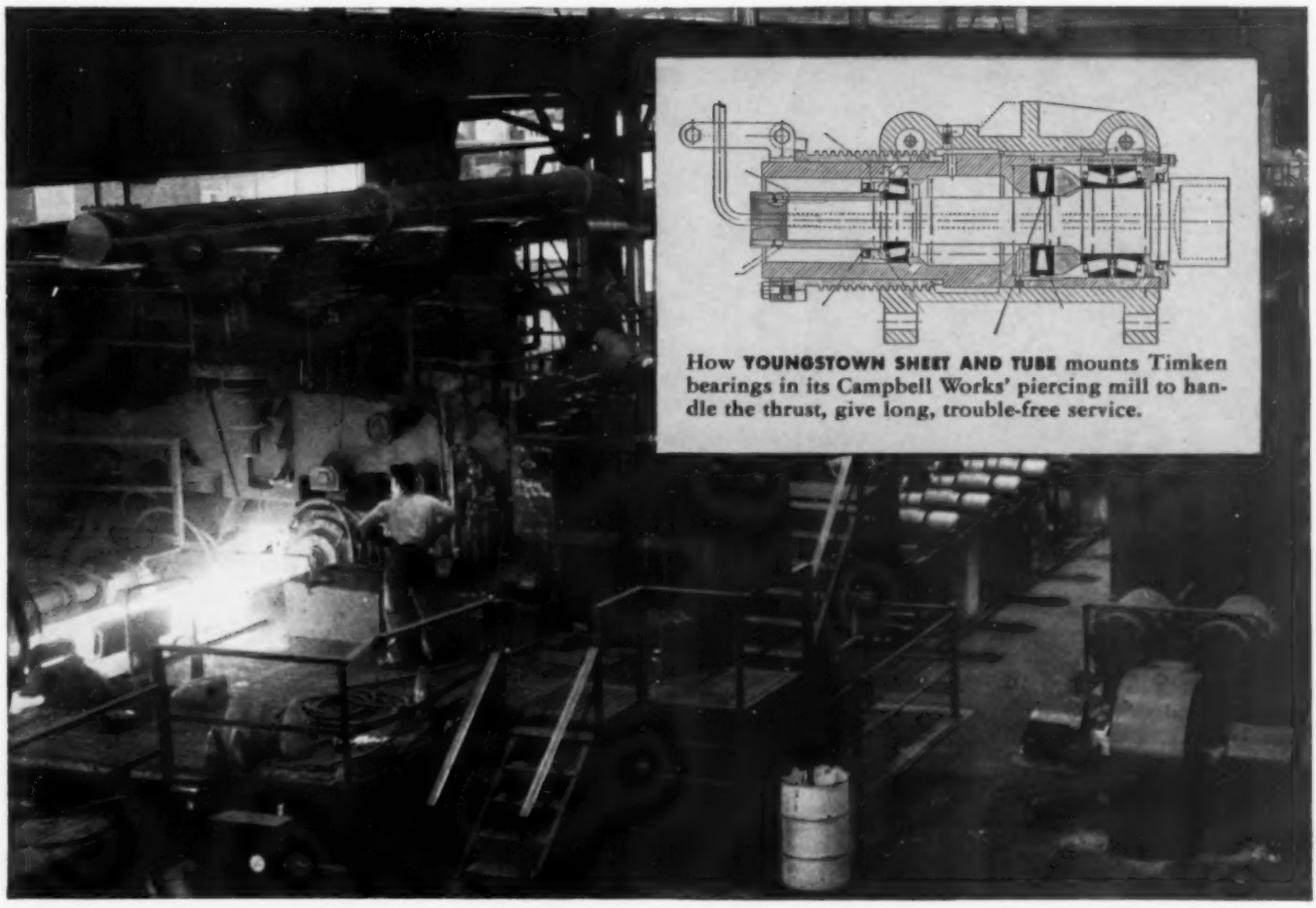
Full line contact between rollers and races is one reason Timken bearings stand up so well on this punishing job. It gives Timken bearings extra load-carrying capacity.

Another reason Timken bearings last and last is because rollers and races are case-hardened. This gives Timken bearings a hard, wear-resistant surface over a tough, shock-resistant core. And wear is reduced because the true rolling motion and incredibly smooth surface finish of Timken bearings practically eliminate friction.

Other Timken bearings in this application (see diagram) help handle some of the thrust. That's because the tapered design of Timken bearings enables them to take *any* combination of radial and thrust loads.

To get these advantages in the equipment you build or buy, always look for the trade-mark "Timken" stamped on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO". Canadian plant: St. Thomas, Ontario.

This symbol on a product means its bearings are the best.



How **YOUNGSTOWN SHEET AND TUBE** mounts Timken bearings in its Campbell Works' piercing mill to handle the thrust, give long, trouble-free service.

IT'S TIMKEN BEARINGS FOR VALUE!

To get the best value in bearings you may find this simple formula helpful:

$$Value = \frac{quality + service + public\ acceptance}{price}$$

Obviously a big advantage *above* the line gives you more value than a small one *below*. No other bearing can match the uniform high quality, engineering and field service and overwhelming public acceptance you get with Timken bearings.

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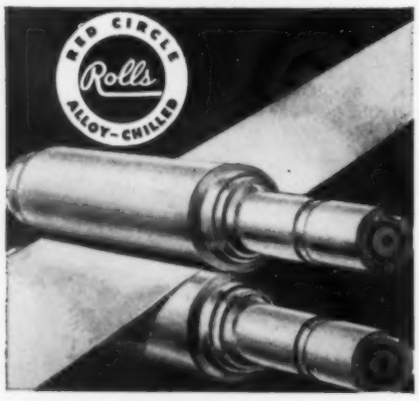

a metalizing-type spray gun. The oxide is fed into the gun in rod form at a carefully controlled rate. Thickness of coating is usually between five and 50 thousandths of an in. although coatings 100 thousandths of an in. thick have been successfully applied.

The coating can be applied to practically any materials. It is extremely hard, has good wear and chemical resistant qualities, is a non-conductor of electricity.

Once applied to metal, the oxide coating will not chip or flake off, even under severe tests.

Silicon carbide coatings have been applied successfully only on graphite shapes up to the present time. While graphite has many desirable properties for use in rockets, it will not withstand high temperatures or erosion adequately. However, a thin coating of silicon carbide provides the needed protection with a negligible increase in weight.

WARNING SIGNAL

▲ Announced by the Pyle-National Co. is a new warning signal for use on many kinds of moving equipment, including emergency vehicles, diesel switcher locomotives, cabooses, cranes and material handling shop

trucks. This new safety device may also be used to mark the location of hazardous areas where workmen may be hidden from the view of moving equipment drivers or operators.

The beam of a sealed beam lamp, used in the new device, is reflected at right angles by the dual inclined plane reflector which revolves at 48 rpm and which projects 96 flashes per min in a horizontal plane. The reflector is mounted directly to the geared motor shaft which requires a minimum of maintenance because all moving parts are limited to the motor components.

A three-wire terminal block is provided in the base of the signal for the motor and lamp leads. The lamp is readily accessible through the gasketed hinged door at the top.

A red enclosing glass cylinder is furnished when this color is specified. Other colors have a clear glass cylinder and a color roundel between the lamp and the reflector.

Book Reviews . . .

"Steam, Its Generation and Use," has just been published in a 37th edition by The Babcock and Wilcox Co. 161 East 42nd Street, New York 17, N.Y. Publication contains 611 pages, 8¼ x 11 in., cloth bound and sells for $10.00 at bookstores. This edition marks tremendous advances in the production of steam and in the burning of fuels. The material contained in this book has been prepared and edited by engineers and specialists of the Babcock and Wilcox Co. and is intended for mechanical engineers and mechanical engineering students in the applied thermo field. Previous editions of this book, first published in 1875, have been accepted as texts in engineering courses of colleges throughout the country.

"A Study of the Iron and Steel Industry in Latin America," Volumes I and II have been published by the United Nations, Department of Economic Affairs, New York, N. Y. These volumes contain the working papers presented by participants of the Expert Working Group on iron and steel industry in Latin America and include a discussion on these papers. Volume I covers economic and marketing topics. Volume II covers technical topics. These deal with reduction of coal impurities, production of coke from poor coking coal and substitute fuels, economics of the blast furnace, charcoal blast furnace, methods of reducing ores other than in blast furnaces, comparison of economics of different processes of steelmaking, methods of rolling and finishing steel, range of application of steels made by different processes and general subjects connected with steelmaking in Latin

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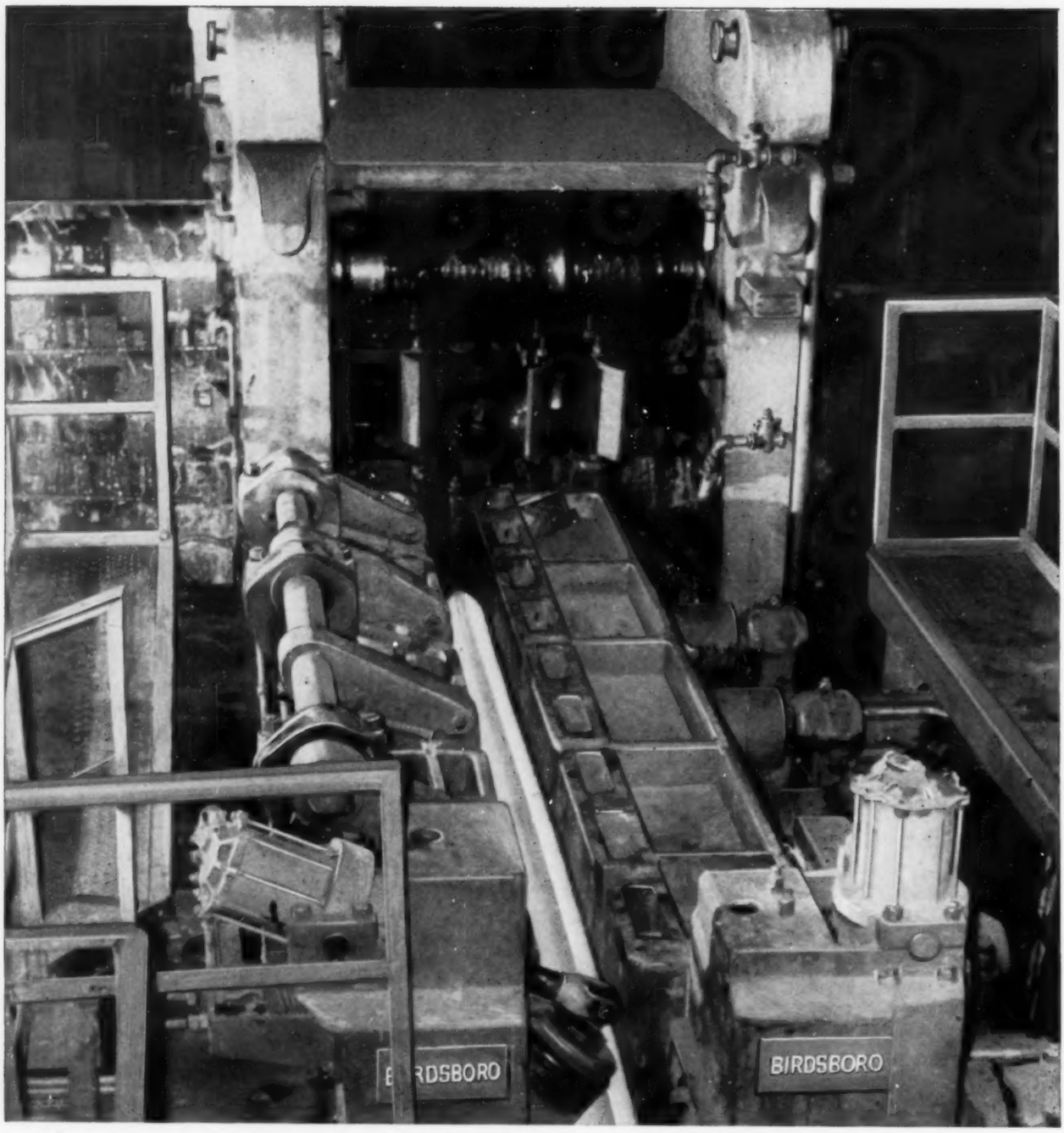

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America. The papers were prepared in 1952 and describe conditions prevailing at that time. Volume I contains 123 pp., 8½ x 11-in., paper bound, price $1.25. Volume II contains 449 pp., 8½ x 11-in., paper bound, and sells for $4.50 in the U. S.

"Professional Engineering Registration Laws," by Alfred L. McCawley has recently been published by the Trustee Publication Fund, Jefferson City, Mo. It contains 614 pp., 5½ x 9-in., cloth bound, price $8.75. The book contains a complete compilation of professional engineering registration laws for all 48 states, Alaska, Hawaii, Puerto Rico, and the District of Columbia. It is an aid to the senior in engineering school and for all experienced professional engineers who might plan to practice in another state or territory. Engineers in government or military service will find this of particular interest. It gives exact legal requirements which must be met in each state including legislative authority for the law, education requirements, number of years experience, examinations, public works projects, fees and bonds, filing of maps, engineer-in-training laws, certificate applications and temporary permits.

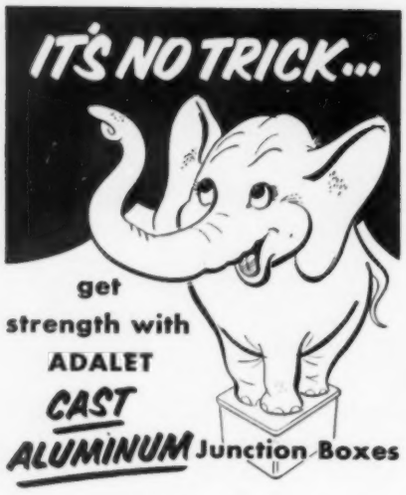
"ASTM Standards on Petroleum Products and Lubricants," has recently been published by the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., containing 980 pp., 6 x 9-in., cloth bound, price $6.65; paper bound, price $6.00. Published annually, this 1955 edition gives the latest approved form for over 100 test methods, numerous specifications, and lists of definitions of terms relating to petroleum. It is a special compilation of specifications, indexes and definitions covering petroleum products and lubricants written in compact and readily usable form. It is helpful to petroleum chemists and other technologists in the industry as well as purchasing agents, sales engineers and those engaged in the automotive, aircraft, railway and other industrial fields.

"Titanium in Iron and Steel," by George F. Comstock, was recently published by John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. It is one of the "Alloys of Iron Research Monograph Series" edited by Frank Sisco. Book contains 294 pp., 5½ x 9-in., cloth bound and sells for $6.00.

This book critically reviews and correlates all the important data in present day literature on titanium as an alloying element in iron and steel. The book begins with a general discussion of titanium and its minerals and examines the properties and effects of the element as an addition to cast iron and steel. Effects in stabilizing nitrogen and fixing of carbon in alloys where other carbides may be undesirable are stressed plus its usefulness in steel which is to be enameled.

"Aluminum Paint and Powder," by Junius D. Edwards and Robert I. Wray, has just been published by the Reinhold Publishing Corp., 430 Park Avenue, New York 22, N. Y. and contains 219 pp., 5½ x 9 in., cloth bound, selling for $4.50. The book is written to answer many questions regarding the present status of aluminum paint when and why it is used and why its applications are increasing. It discusses the manufacture, properties and testing of aluminum powder placing stress on the processes involved, color, brilliance, leafing, density, grading and handling. A large section is devoted to uses of aluminum powder in the arts. Applications of aluminum in printing inks, metallized paper, coated textiles, powder metallurgy, plastics, rubber, explosives, concrete, lubricants, medicine and many other fields are explored.

"Heating Ventilating Air Conditioning Guide 1955," has very recently been published in a 33rd edition by the American Society of Heating and Air-Conditioning Engineers, Inc., 62 Worth Street, New York 13, N. Y. This edition with its up-to-date information contains 1680 pp., 6 x 9-in., is cloth bound and sells for $12.00 per copy. The book has been printed to include many important improvements in the subject and contains data in complete detail on behavior of moisture in its transfer through building construction, design of gravity and forced warm air systems, dis-



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tric heating, and corrosion and scale prevention in equipment and systems. Information for the first time is included on high temperature water systems.

"English-German and German-English Dictionary for the Iron and Steel Industry," by Eduard L. Kohler has recently been published in Vienna, Austria by Springer-Verlag in Wien 1, Milkerbastei 5. This publication provides 162 pages of steel mill engineering terms, 6 x 8½-in., cloth bound and sells for $6.65. The author has tried to put forth in this dictionary the linguistic result of long years of translating and interpreting work for a large iron and steel company in Austria. It was written to provide a useful guide for the benefit of the steel plant engineer and translator.

"General Principles of Geology," by J. F. Kirkaldy, has recently been published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y., 327 pp., 6 x 9½-in., cloth bound, price $6.00. This book places emphasis on the main principles of geological science which are the same whether applied to economic or to purely academic needs. It is an introduction to those interested in the subject and also serves as a starting point for specialized work on more limited aspects, such as the search for minerals, oil and coal.

"Protective Coatings for Metals," by R. M. Burns and W. W. Bradley has been published in a second edition by the Reinhold Publishing Corp., 430 Park Avenue, New York 22, N. Y., 643 pp., 5½ x 9-in., cloth bound, price $12.00. This book which is monograph No. 129 of the American Chemical Society Series, is well written by qualified authors. It has been practically all rewritten and brings the most recent information known on the composition, properties and performance of both metallic and organic coatings. It contains an expanded section on evaluation of organic coatings, new chapters on corrosion inhibitors, chemical conversion coatings, sprayed metal coatings and full explanations of many troublesome phenomena and other up to date items on these subjects. It is of definite interest to corrosion engineers, metallurgists and chemists.

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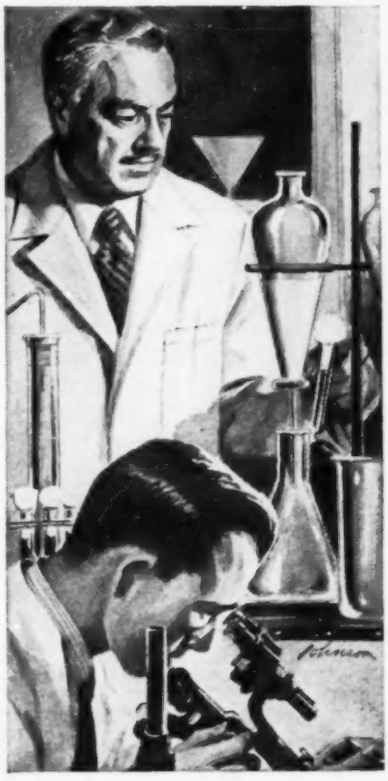

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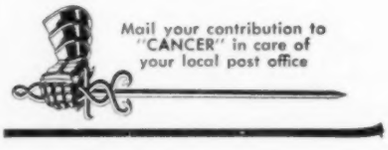

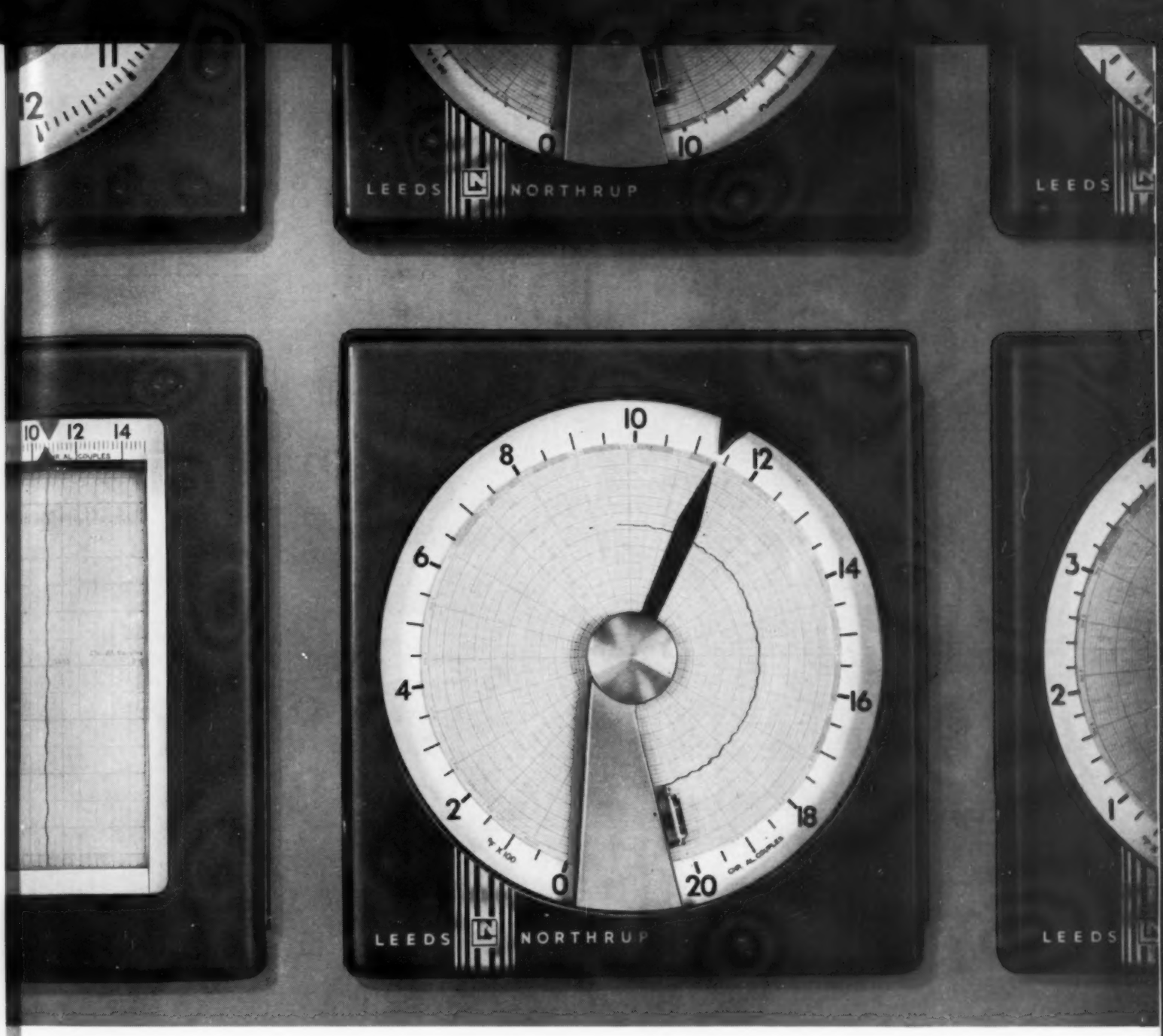

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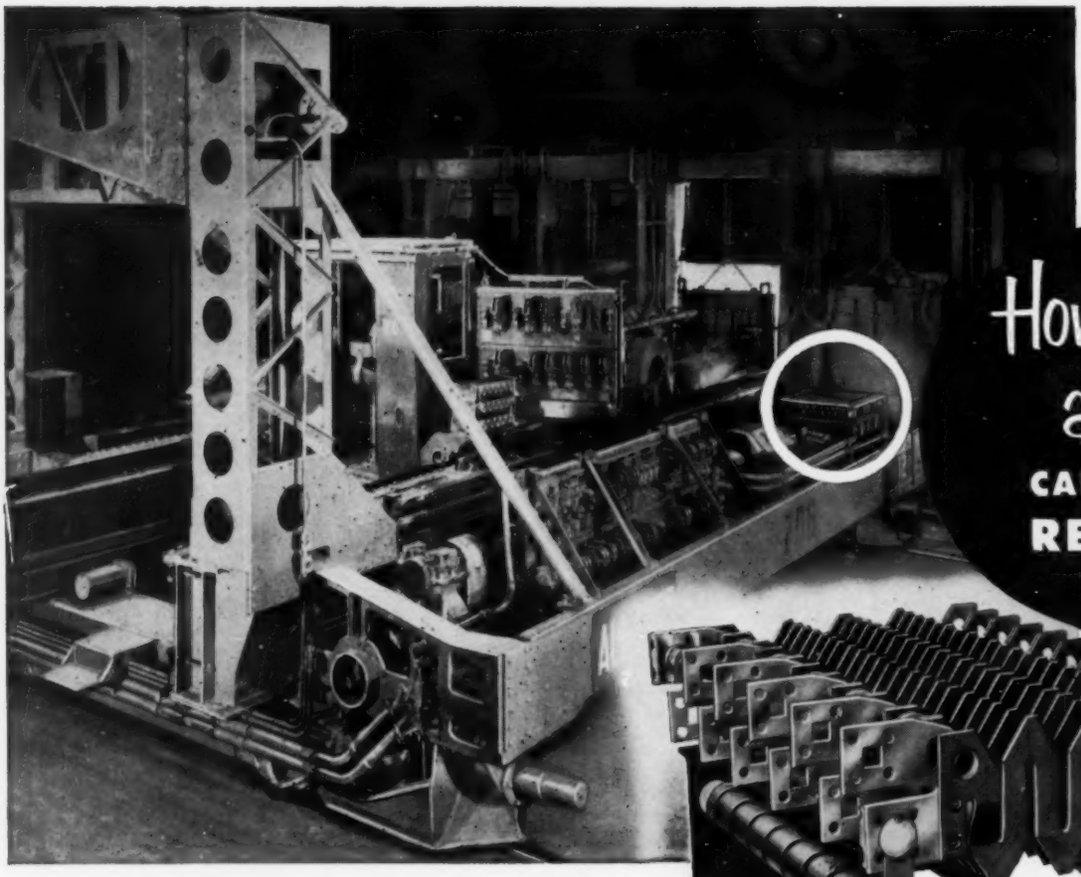

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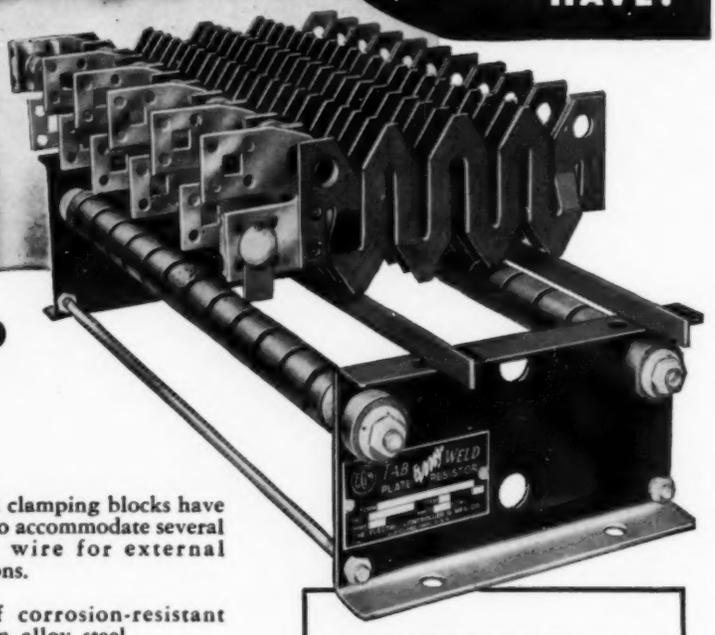

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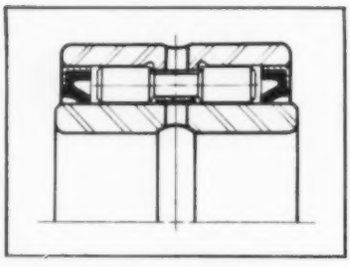
Above: McGill's new sealed Guiderol** bearing with two *built-in* springless KLOZURES, Model 71-A. *Left:* The Model 71-A has a narrow cross section consisting of a molded synthetic rubber sealing member securely bonded to and integral with a metal case.



Two springless KLOZURES, lips turned in, on Guiderol bearing provide lifetime retention of lubricant. For relubricating at high pressures other sealing arrangements (with lips turned out; with one lip in and one out; and single seals) are available with these bearings.

In developing their new sealed Guiderol bearing, the designers of McGill Manufacturing Co., Inc., (Valparaiso, Ind.) required a dependable grease seal which could be built into the unit *without* increasing the overall bearing size.

Springless KLOZURE Model 71-A proved to be the answer! For here was a proven grease seal of narrow cross section specifically designed for limited space applications. Here, also, was a trouble-free seal which would keep out dust and retain the lubricant for the *life of the bearing.*

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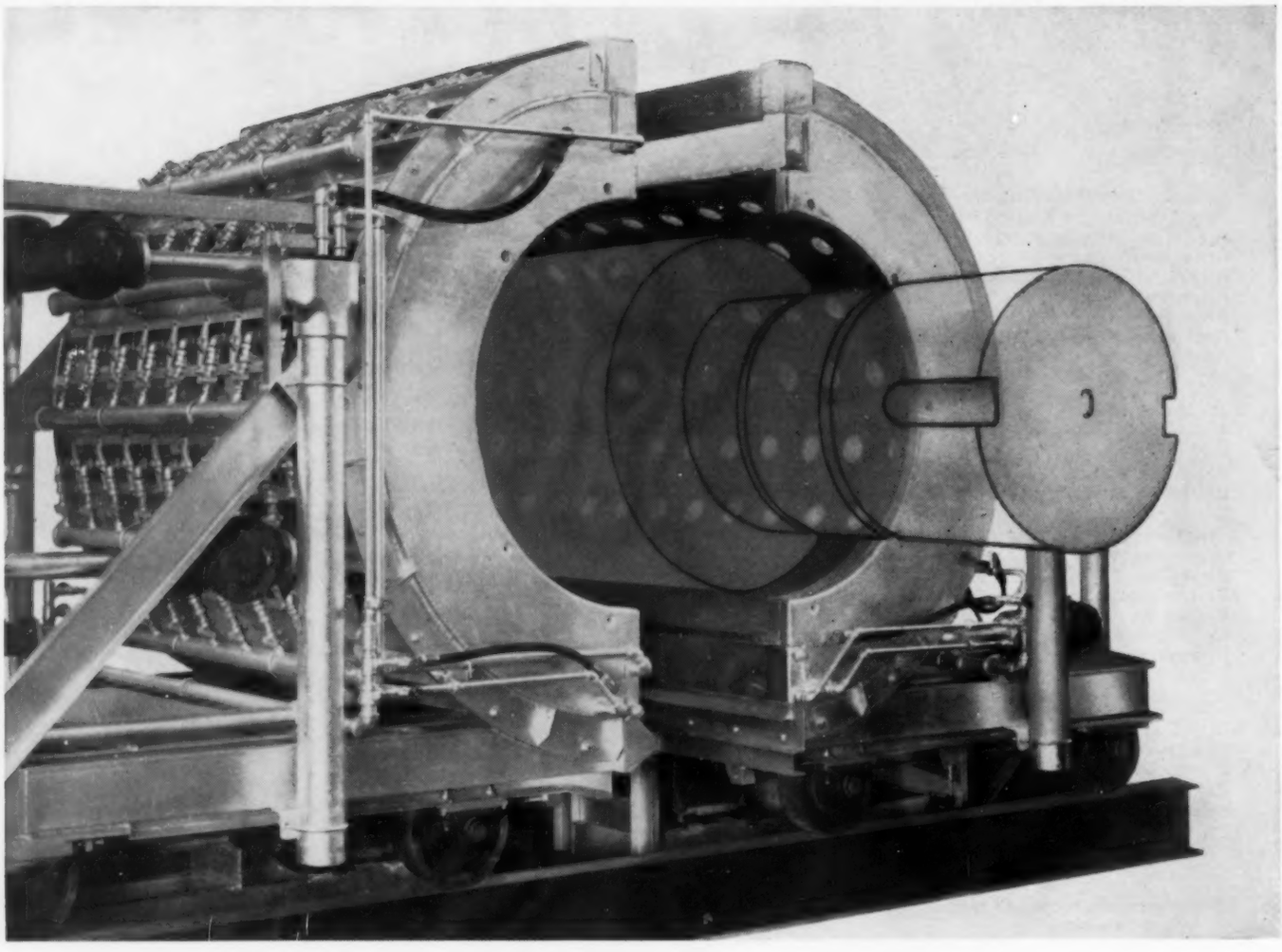

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Studies in Centralized Lubrication
No. 174

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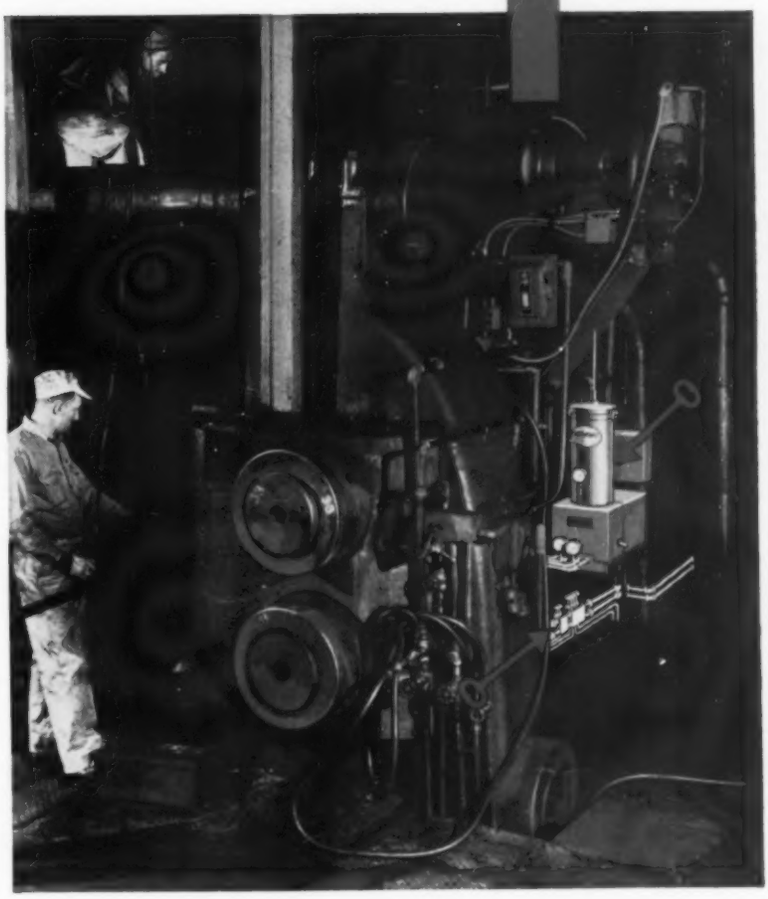

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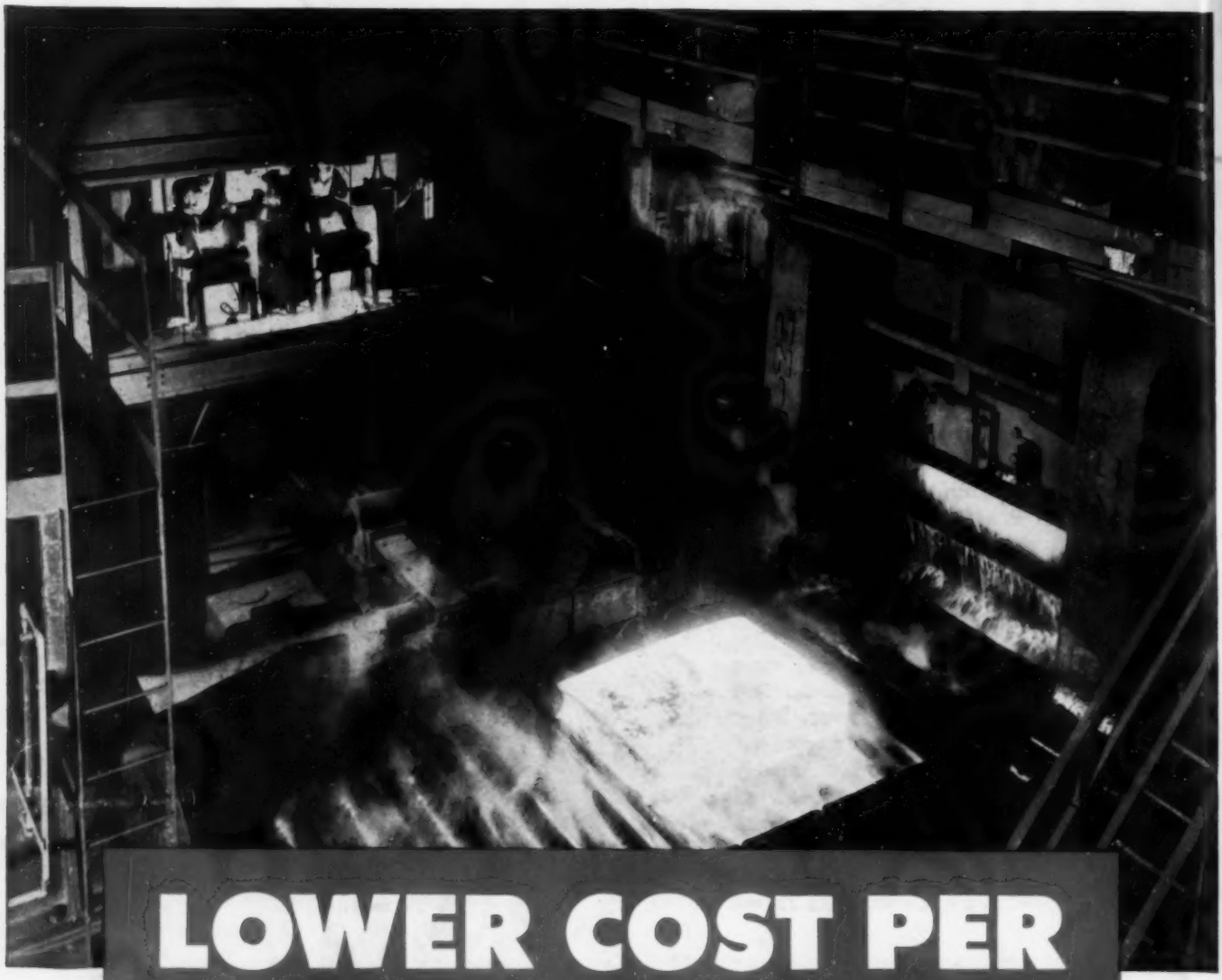

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